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U.S. Department of Energy
Idaho Operations Office

Composite Analysis for the INEEL CERCLA Disposal Facility Landfill

INEEL
Home of Science and Engineering Solutions
Idaho National Engineering and Environmental Laboratory

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ABSTRACT

This Composite Analysis (CA) for the INEEL CERCLA Disposal Facility (ICDF) landfill documents the projected cumulative radiological dose to future members of the public from the ICDF landfill and all other sources of radioactive contamination at the INEEL that could interact with the dose from the ICDF landfill. The impacts are compared with applicable U.S. Department of Energy (DOE) dose criteria as well as relevant U.S. Environmental Protection Agency (EPA) standards.

The CA consists of a conceptual model that links radionuclide inventory, release (or source term), environmental transfer, and impact assessment and culminates in radiological all-pathways total effective dose equivalent (EDE) to receptors. The groundwater all-pathways scenario (ingestion of contaminated drinking water, contaminated produce, and contaminated meat and dairy products) was considered for this CA in addition to groundwater protection criteria as outlined in the ICDF performance assessment, which is based on 40 CFR 141, "National Primary Drinking Water Regulations."

The projected groundwater all-pathways dose is less than both the primary dose limit of 100 mrem/yr and the dose constraint of 30 mrem/yr. An options analysis was not prepared because the CA dose limit of 30 mrem/yr was not exceeded.

EXECUTIVE SUMMARY

The composite analysis (CA) estimates the projected cumulative impacts to future members of the public from the disposal of low-level radioactive waste (LLW) at the INEEL CERCLA Disposal Facility (ICDF) landfill and all other sources of radioactive contamination at the Idaho National Engineering and Environmental Laboratory (INEEL) that could interact with the LLW disposal facility to affect the radiological dose. The impacts are compared with applicable U.S. Department of Energy (DOE) dose criteria as well as relevant U.S. Environmental Protection Agency (EPA) standards.

The purpose of the ICDF landfill is to consolidate INEEL Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) wastes into one engineered facility. The LLW radiological performance assessment for the ICDF landfill presents a comprehensive, systematic analysis of the long-term impacts of LLW disposal in an arid, near-surface environment. This CA shows the cumulative impact to the Snake River Plain Aquifer of the ICDF landfill together with other INEEL radionuclide sources.

Based upon the CA evaluation, Idaho Nuclear Technology and Engineering Center (INTEC) area facilities are the only sources of radioactive contamination at the INEEL that will significantly interact with the ICDF landfill. The source term used in the CA consists of all significant INTEC sources as well as projected inventory for the ICDF landfill. The CA source term was obtained from the ICDF performance assessment (DOE-ID 2003a) and is based on radionuclide inventories reported in the design documentation for the ICDF. Source terms for the other INTEC facilities were obtained from previous evaluations of these facilities.

The CA evaluation consists of a conceptual model that links radionuclide inventory, release (or source term), environmental transfer, and impact assessment and culminates in radiological all-pathways total effective dose equivalent (EDE) to receptors. Exposure scenarios are the link between contaminated environmental media (i.e., groundwater) and the exposure of a hypothetical receptor. The groundwater all-pathways scenario (ingestion of contaminated drinking water, contaminated produce, and contaminated meat and dairy products) was considered for this CA in addition to groundwater protection criteria as outlined in the ICDF performance assessment, which is based on 40 CFR 141.

The all-pathways dose was calculated at four primary receptor locations. During the period of institutional control (years 2018–2118), the receptor is at the INEEL Site southern boundary. Afterwards, the receptor is assumed to be 100 m (328 ft) downgradient of the ICDF landfill. To verify that these four receptors bound the potential locations for receptors, the all-pathways dose at year 2118 was predicted for a series of wells downgradient from INTEC to the boundary of the INEEL. In year 2118, the peak all-pathways dose is at the receptor closest to the INTEC. Therefore, after year 2118, the peak all-pathways dose will always be at Receptors 1, 2, or 3. Therefore, results will only be presented for Receptor 4 during the institutional control period and Receptors 1, 2, and 3 afterwards. For the analyses, three receptors were defined along an east-west line. Groundwater all-pathways dose to a hypothetical future member of the public was estimated for the following time periods:

- Institutional control period for 100 years from the projected closure of the landfill in year 2018 until the year 2118. The institutional control period not only includes the ICDF landfill but it also encompasses the land south to the INEEL Site boundary.

- Compliance period for 900 years from year 2118 until the year 3018. However, institutional controls will still be in place at the ICDF landfill per the ROD requirements.

- Postcompliance period from year 3018 to year 100,000.

Table ES-1 presents the results of the CA and compares them with the performance objectives for the groundwater all-pathways and groundwater protection scenarios. The predicted peak groundwater all-pathways dose for the period of institutional control is 7.8 mrem/yr. The predicted peak groundwater all-pathways dose during the compliance period (years 2118–3018) is 8.1 mrem/yr.

The projected groundwater all-pathways dose is less than both the DOE primary dose limit of 100 mrem/yr and the dose constraint of 30 mrem/yr. An options analysis was not prepared because the CA dose limit of 30 mrem/yr was not exceeded.

Table ES-1. Comparison of the ICDF landfill CA-predicted results with performance objectives for groundwater all-pathways dose and groundwater protection.

Performance Objective	Regulatory Reference	Institutional Control Period (Receptor 4)	Compliance Period Until the Year 3018 (Receptor 2)	Postcompliance Period Until the Year 100,000 (Receptor 1)
100 mrem/yr (DOE primary dose limit) and 30 mrem/yr (DOE CA dose limit for options analysis)	All-pathways	7.8 mrem/yr	8.1 mrem/yr	4.6 mrem/yr
4 mrem/yr man-made beta-gamma CDE[a]	Groundwater protection	69 mrem/yr	0.19 mrem/yr	40 mrem/yr
5 pCi/L Ra-226 and Ra-228 concentration[a]	Groundwater protection	0.0 pCi/L	2.6E-04 pCi/L	0.029 pCi/L
15 pCi/L adjusted gross alpha concentration[a]	Groundwater protection	0.0 pCi/L	2.1 pCi/L	1.3 pCi/L
20 µg/L uranium concentration[a]	Groundwater protection	0.00 µg/L	9.5 µg/L	5.5 µg/L

a. Derived from current and proposed maximum contaminant levels.

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FIGURES

TABLES

ACRONYMS

ALARA	as low as reasonably achievable
ANL-W	Argonne National Laboratory-West
ARA	Auxiliary Reactor Area
BEA	Bureau of Economic Analysis
BLM	U.S. Bureau of Land Management
BORAX	Boiling Water Reactor Experiment
CA	composite analysis
CDC	Conservation Data Center
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	Chemical Processing Plant (used for building numbers)
DCF	dose conversion factor
DOC	U.S. Department of Commerce
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
EA	environmental assessment
EBR-I	Experimental Breeder Reactor-I
EDE	effective dose equivalent
EDF	Engineering Design File
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESRP	Eastern Snake River Plain

FECF	Fuel Element Cutting Facility
FRSF	Fuel Receiving and Storage Facility
HLW	high-level waste
ICDF	INEEL CERCLA Disposal Facility
ICPP	Idaho Chemical Processing Plant
IDAPA	Idaho Administrative Procedures Act
IDFG	Idaho Department of Fish and Game
IDW	investigation-derived waste
IFSF	Irradiated Fuel Storage Facility
INEEL	Idaho National Engineering and Environmental Laboratory
INPS	Idaho Native Plant Society
INTEC	Idaho Nuclear Technology and Engineering Center
LITCO	Lockheed Idaho Technologies Company
LLW	low-level waste
MCL	maximum contaminant level
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NWCF	New Waste Calcining Facility
OU	operable unit
PA	performance assessment
PBF	Power Burst Facility
PCB	polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
RESL	Radiological and Environmental Sciences Laboratory
RI/BRA	remedial investigation/baseline risk assessment
RI/FS	remedial investigation/feasibility study

ROD	record of decision
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SRPA	Snake River Plain Aquifer
SSSTF	Staging, Storage, Sizing, and Treatment Facility
TAN	Test Area North
T/E	threatened or endangered
TFF	Tank Farm Facility
TRA	Test Reactor Area
TSCA	Toxic Substances Control Act
UCL	upper confidence limit
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	universal transverse mercator
VWG	Volcanism Working Group
WAC	Waste Acceptance Criteria
WAG	waste area group
WCF	Waste Calcining Facility
WCFS	Woodward-Clyde Consultants Federal Services
WIPP	Waste Isolation Pilot Plant

Composite Analysis for the INEEL CERCLA Disposal Facility Landfill

1. INTRODUCTION

The U.S. Department of Energy (DOE) requires a composite analysis (CA), in addition to either a performance assessment (PA) pursuant to DOE Order 435.1 or risk assessments pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), for each active and planned low-level radioactive waste (LLW) disposal facility. The U.S. Department of Energy Idaho Operations Office (DOE-ID) authorized a remedial design/remedial action for the Idaho Nuclear Technology and Engineering Center (INTEC) in accordance with the Waste Area Group (WAG) 3, Operable Unit (OU) 3-13 Record of Decision (ROD) (DOE-ID 1999). The ROD requires the removal and on-Site disposal of some of the CERCLA remediation wastes generated within the boundaries of the Idaho National Engineering and Environmental Laboratory (INEEL). The INEEL CERCLA Disposal Facility (ICDF) landfill was built to consolidate INEEL CERCLA wastes into one engineered facility to reduce the footprint of contamination across the INEEL.

The ROD requirements necessitated the construction of the ICDF, which will be the disposal facility for the INEEL CERCLA waste streams. The ICDF is an on-Site, engineered facility, located south of INTEC, that meets the substantive requirements of Resource Conservation and Recovery Act (RCRA), Subtitle C, and the Toxic Substances Control Act (TSCA) polychlorinated biphenyl (PCB) landfill design and construction requirements. The ICDF Complex was designed to include the necessary subsystems and support facilities to provide a complete waste disposal system. When operations begin, it will accept not only WAG 3 wastes, but also wastes from other INEEL CERCLA actions.

The major components of the ICDF Complex include the landfill, an evaporation pond comprised of two cells, and the Staging, Storage, Sizing, and Treatment Facility (SSSTF). The ICDF landfill will only accept radioactive low-level, mixed low-level, hazardous, and TSCA wastes generated from INEEL CERCLA activities. Current projections of Site-wide CERCLA waste volumes total about 389,923 m^3 (510,000 yd^3) (DOE-ID 1999). Most of the waste will be contaminated soil, but debris and CERCLA investigation-derived waste (IDW) are also included in the waste inventory. The ICDF landfill will begin accepting waste for disposal by the end of FY 2003 and will accept solid waste for a 15-year operations period, with an anticipated closure date of 2018.

1.1 General Approach

The CA assesses potential dose to hypothetical future members of the public from the aggregate of residual radioactive material that is likely to remain on the INEEL and that is likely to add to the dose from the planned ICDF landfill. The CA results will be used for planning, radiation protection activities, and future use commitments to ensure that ICDF landfill low-level waste disposal activities will not result in the need for future corrective or remedial actions to adequately protect the public and the environment.

A primary dose limit of 100 mrem/yr, total effective dose equivalent, is the basic performance measure (DOE O 5400.5). However, to ensure the potential dose from the aggregate of sources analyzed is not likely to exceed a significant fraction of the primary dose limit, an administratively limited dose constraint of 30 mrem/yr is adopted. If the dose calculated in the CA exceeds 30 mrem/yr, then an options analysis will be prepared to consider actions that could be taken to reduce the calculated dose and to consider the cost of those actions.

The general approach taken for this CA is to take the groundwater all-pathways (ingestion of contaminated drinking water, contaminated produce, and contaminated meat and dairy products) dose results from the *Performance Assessment for the INEEL CERCLA Disposal Facility Landfill* (DOE-ID 2003a) and add them to the groundwater all-pathways dose results for all other INEEL sources that may interact with the ICDF landfill dose results to affect the dose to future members of the public. The primary pathway for the migration of radionuclides from the ICDF landfill is the underlying Snake River Plain Aquifer (SRPA). Therefore, the main purpose of this CA is to assess the potential impact of radioactive releases from the ICDF landfill and other INEEL release sites on the regional groundwater flow system.

1.2 Site Description

The ICDF Complex is located at INTEC, a southern facility on the INEEL (Figure 1-1). The site selected for the ICDF Complex is adjacent to Lincoln Boulevard and situated at the southwest corner of the INTEC facility, outside the facility fence (Figures 1-2 and 1-3). The Staging, Storage, Sizing, and Treatment Facility (SSSTF) is the northernmost Complex component, directly to the west of the INTEC facility fence. To the south of the SSSTF is the ICDF landfill. To the east of the landfill is the evaporation pond, which is composed of two cells, referred to as the east and west cells. Fencing will be maintained around the ICDF Complex to provide security of the components and control of the waste handling practices. The location of the ICDF Complex allows for easy access from Lincoln Boulevard, the main INEEL road between facilities. This will allow controlled yet straightforward access to the ICDF Complex components, as needed, for WAG waste management.

The landfill is designed to be protective of the SRPA, such that groundwater contamination does not exceed applicable State of Idaho groundwater quality standards. The landfill is designed for an operational life of 15 years, a postclosure period of 30 years, and a cover design life of 1,000 years. The landfill cover is designed to minimize infiltration and run-on and maximize run-off by maintaining a sloped surface, storing water for later release to the atmosphere, providing lateral drainage, and providing a low-permeability composite liner barrier system. The final cover is designed to protect the disposed waste for a period of 1,000 years. Design requirements include a liner system and leachate collection and removal system. The liner system is comprised of (1) a primary liner designed and constructed of materials (e.g., a membrane) to prevent the migration of hazardous constituents into such liner during the active and postclosure care period and (2) a composite secondary liner with the lower component constructed of at least 0.91 m (3 ft) of compacted soil/bentonite material with a hydraulic conductivity of no more than 1E-07 cm/sec. The leachate collection and removal system is designed, constructed, operated, and maintained to collect and remove leachate from the landfill during the active life and postclosure care period. For more complete details on the landfill design refer to the *INEEL CERCLA Disposal Facility Remedial Design/Construction Work Plan* (DOE-ID 2002a).

Landfill-specific Waste Acceptance Criteria (WAC) (e.g., numerical chemical and radiological concentrations) have been developed for the landfill and are included in the WAC document (DOE-ID 2002b). Development of the radiological acceptance criteria for the landfill included calculations to determine concentrations in the ICDF landfill leachate that are protective of the SRPA, human health, and the environment. The ICDF Complex users must specify waste content and obtain approval from the ICDF Complex operations manager prior to shipment. Wastes that can be accepted at the ICDF landfill include

- WAG 3 CERCLA remediation wastes, including soils, drill cuttings, building debris, boxed soils, and secondary remediation wastes, such as personal protective equipment.

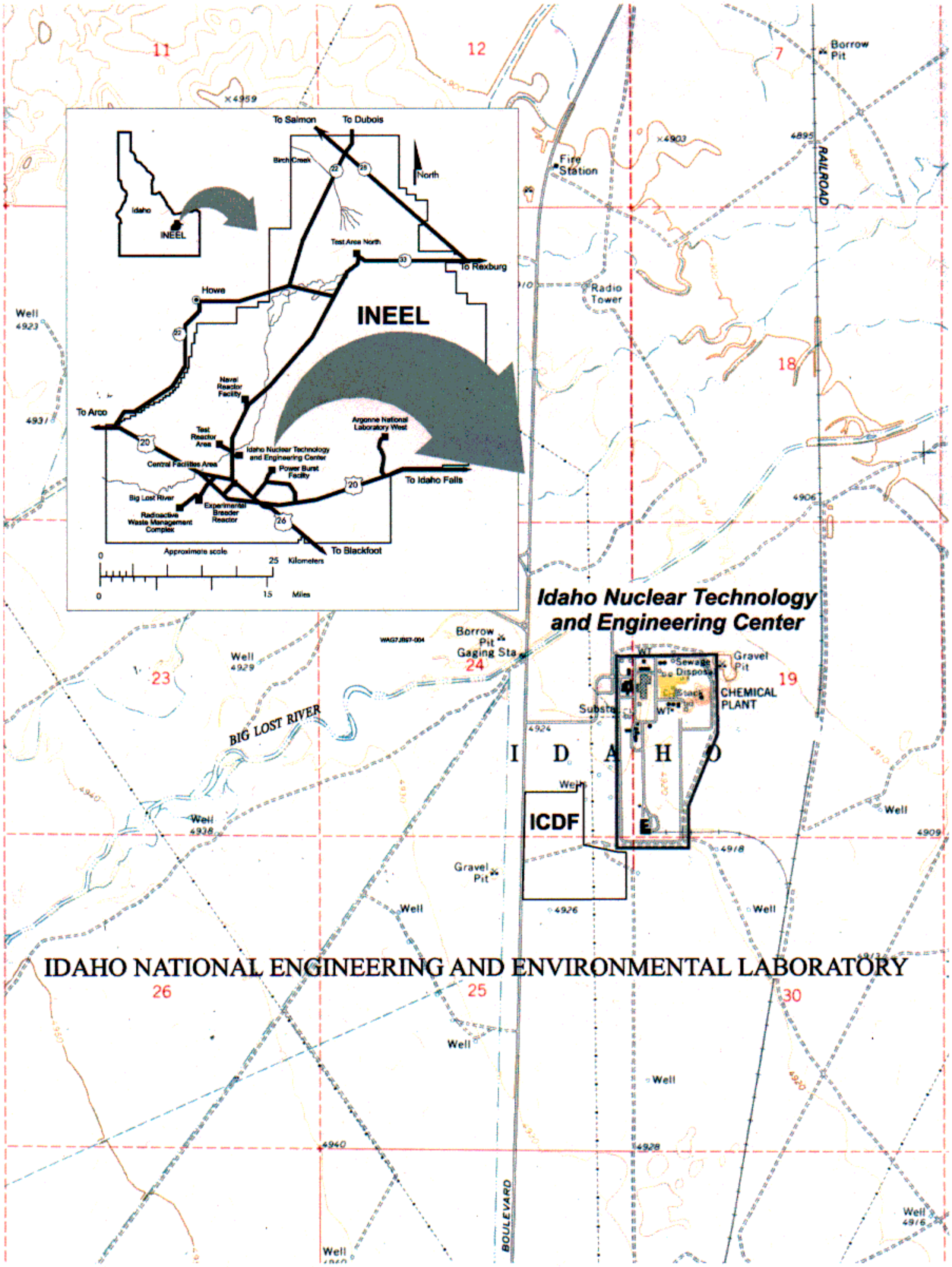

Figure 1-1. Map showing location of Idaho Nuclear Technology and Engineering Center.

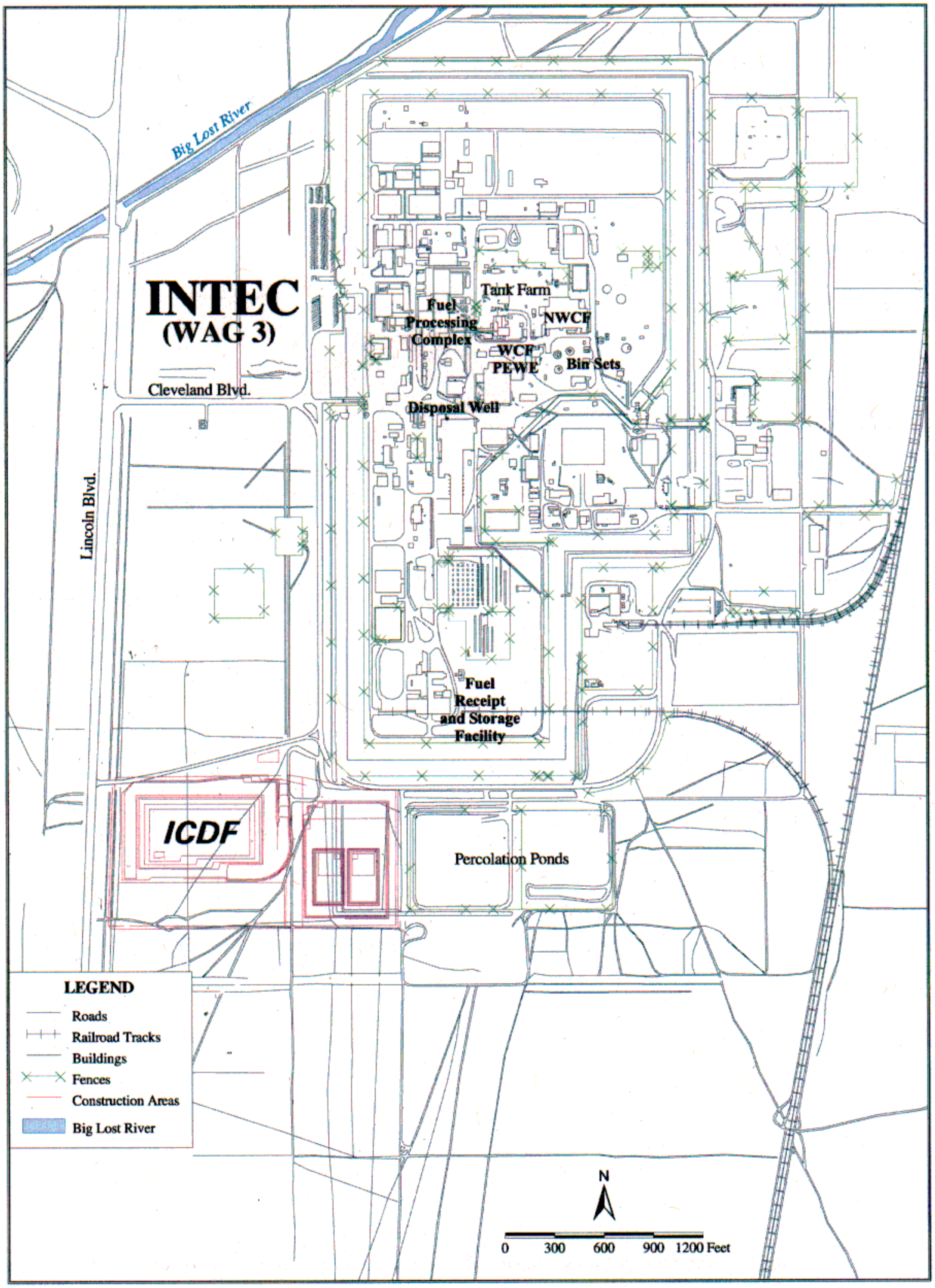

Figure 1-2. Location of the ICDF Complex.

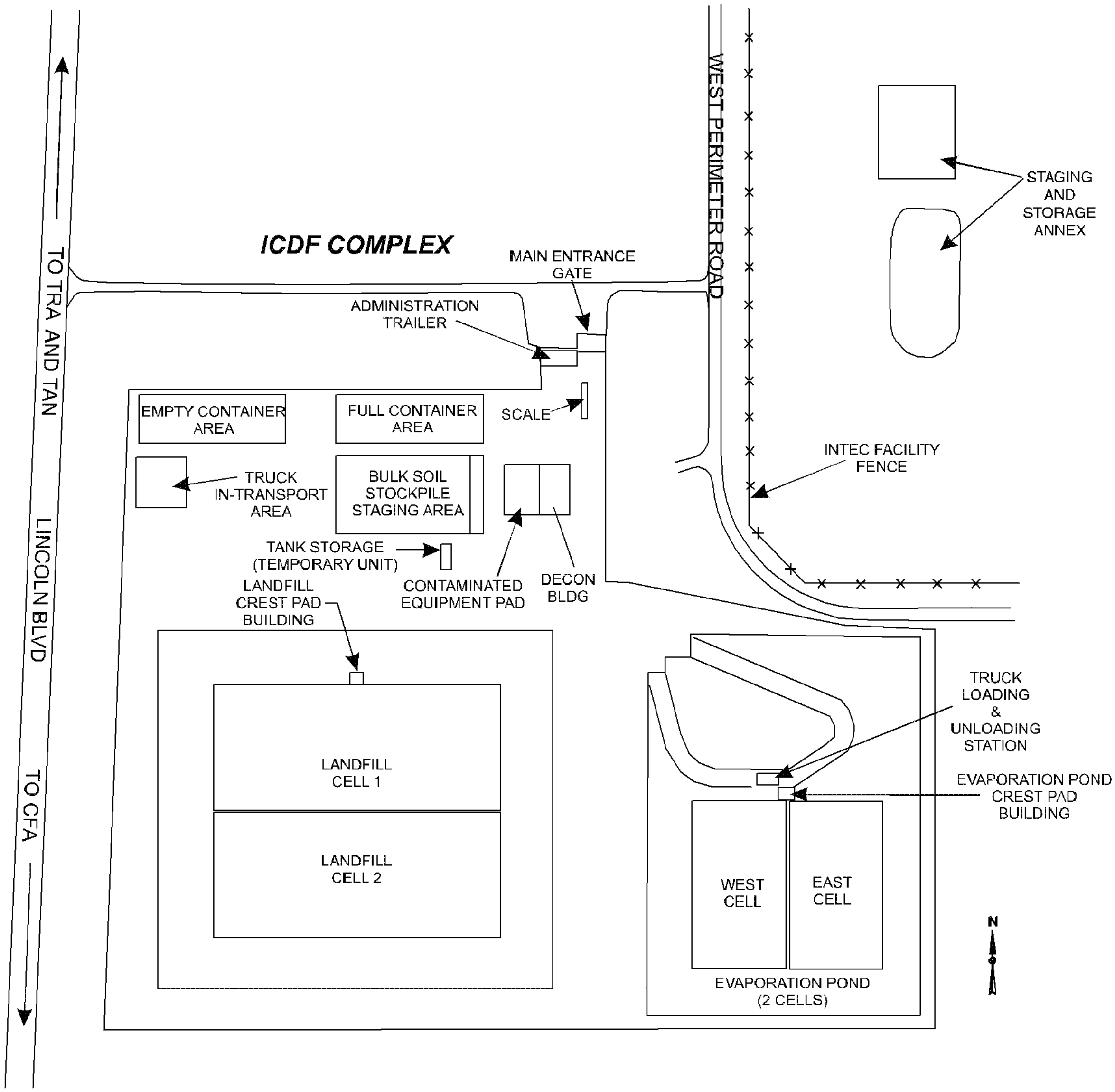

Figure 1-3. Detailed layout of ICDF Complex.

- Wastes generated in the ICDF Complex and from CERCLA investigative, remedial, and removal activities at the INEEL WAGs. These wastes will include soils, drill cuttings, building debris, stabilized wastes, and secondary remediation and investigation wastes.

- Secondary CERCLA wastes from waste processing and decontamination activities in the ICDF Complex.

The ICDF landfill WAC document provides limits for the quantities of radioactive materials that may be accepted for disposal at the ICDF landfill (DOE-ID 2002b). These limits are based on the remedial action objectives outlined in the OU 3-13 ROD (DOE-ID 1999), which include prevention of the release of leachate to underlying groundwater that would result in exceeding a cumulative carcinogenic risk of 1E-04 or applicable State of Idaho groundwater quality standards. In addition, the expected leachate concentrations must be compatible with the earthen and synthetic materials of the ICDF landfill liner system. For radionuclides, the maximum allowable concentrations in leachate for liner compatibility are an absorbed dose of 1,000,000 rad/cm^2 while the design inventory concentrations would result in 17,000 rad/cm^2 (DOE-ID 2002b).

Waste material will go through an acceptance process at the ICDF Complex that includes weighing, profiling, verification, acceptance, quality assurance, and database management before the material will proceed to the ICDF landfill and evaporation pond.

1.2.1 General Land Use Patterns

The *INEEL Comprehensive Facility & Land Use Plan* (DOE-ID 1996) and the INTEC Final Record of Decision (DOE-ID 1999) describe the land use for the INEEL and INTEC. Land use at the INEEL is currently government-controlled industrial use. Presently, access to INEEL facilities requires proper clearance, training, or escort and controls to limit the potential for unacceptable exposures. A security force is used to limit access to approved personnel and visitors. These controls are estimated to be in place for the next 100 years.

The primary use of INEEL land currently is to support facility and program operations dedicated to nuclear energy research, spent nuclear fuel management, hazardous and mixed waste management and minimization, cultural resources preservation, and environmental engineering protection and remediation. Large tracts of land are reserved as buffer and safety zones around the boundary of the INEEL. Portions within the central area are reserved for INEEL operations. The remaining land within the core of the reservation, which is largely undeveloped, is used for environmental research, ecological preservation, and sociocultural preservation. Figure 1-4 illustrates the different land-use classifications in and around the INEEL.

Approximately 77% of the land in the five counties surrounding the INEEL is considered open range land, forest, or barren (DOE-ID 1995). Roughly 21% of the land in these counties is used for farming. Somewhat less than 2% of the land in the surrounding counties is surface water or wetland, and only about 0.3% of the land in the counties is considered urban. The land outside the INEEL boundary closest to the INTEC is primarily Bureau of Land Management (BLM) –controlled with small pockets of state-controlled or private, noncultivated land.

Future land use is addressed in the INEEL future land-use scenarios document (DOE-ID 1995) and in the *INEEL Comprehensive Facility & Land Use Plan* (DOE-ID 1996). Future land use during the 1,000-year period most likely will remain essentially the same as the current use: a research facility within the INEEL boundaries and agriculture and open land surrounding the INEEL. Other potential, but less likely, land uses within the INEEL include agriculture and the return of the areas on-Site to their natural, undeveloped state.

Planning assumptions for land use within and adjacent to the INEEL are that the INEEL will remain under government control for at least the next 100 years and no new major, private developments (residential or nonresidential) are expected in areas adjacent to the INEEL. This CA assumes that the institutional control period begins at the end of closure for the ICDF landfill. The anticipated date of closure for the ICDF landfill is 2018. Therefore, the end of institutional control is assumed to be 2118 for the purposes of dose calculations in this CA. The closure strategy for the landfill assumes an engineered cover with institutional and land-use controls. The cover is designed to last through the performance period of 1,000 years.

The following sections provide a basic overall description of the INEEL site and environs including the location of the disposal facility, the general land surface features of the site, the population distribution in the area, and uses of adjacent lands.

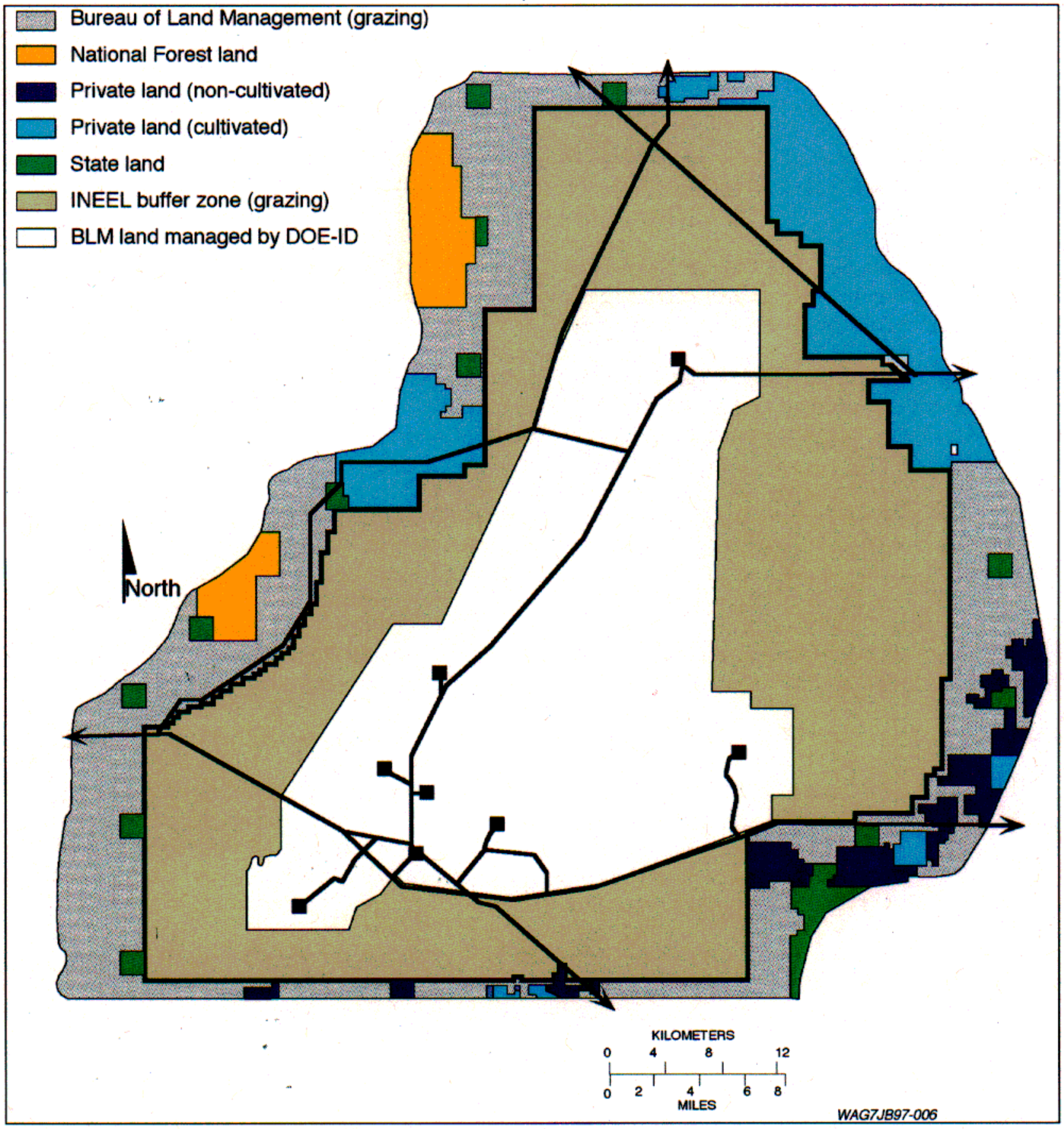

Figure 1-4. Land-use designations in and around the INEEL.

1.2.2 Regional Geography

The INEEL is located in southeastern Idaho, on the north-central part of the Eastern Snake River Plain (Figure 1-5). Included in its 2,305 km^2 (890 mi^2) of area are portions of five Idaho counties (Bingham, Bonneville, Butte, Clark, and Jefferson). The nearest INEEL boundaries are 51 km (32 mi) west of Idaho Falls, 37 km (23 mi) northwest of Blackfoot, 71 km (44 mi) northwest of Pocatello, and 11 km (7 mi) east of Arco, Idaho. There are no permanent residents within a 17.7-km (11-mi) radius of INTEC. The INEEL is approximately equidistant from the three larger metropolitan areas of Salt Lake City, UT, 339 km (211 mi); Boise, ID, 413 km (257 mi); and Butte, MT, 344 km (214 mi) (DOE-ID 1993a).

The ICDF Complex is adjacent to the southern INEEL facility INTEC. INTEC occupies approximately 80 ha (200 ac) in the south-central portion of the INEEL and consists of more than 150 buildings. Primary facilities at INTEC include storage, treatment, and laboratory facilities for spent nuclear fuel, mixed high-level waste (HLW), and mixed transuranic waste (sodium-bearing waste). Located outside the INTEC perimeter fence are parking areas, a helicopter landing pad, the wastewater treatment lagoon, various pits, and percolation ponds which were recently taken off-line in August 2002. These areas occupy approximately 22 ha (55 ac). The site selected for the ICDF Complex is adjacent to Lincoln Boulevard and situated at the southwest corner of the INTEC facility, outside the facility fence.

The SSSTF is the northernmost ICDF Complex component, directly to the west of the INTEC facility fence. To the south of the SSSTF is the ICDF landfill, which is composed of two cells. Cell 1, the northernmost cell, will be filled first and expanded into Cell 2. To the east of the landfill is the evaporation pond, which is also composed of two cells, referred to as the east and west cells. The evaporation pond is directly south of the INTEC facility fence. Two crest pad buildings will provide

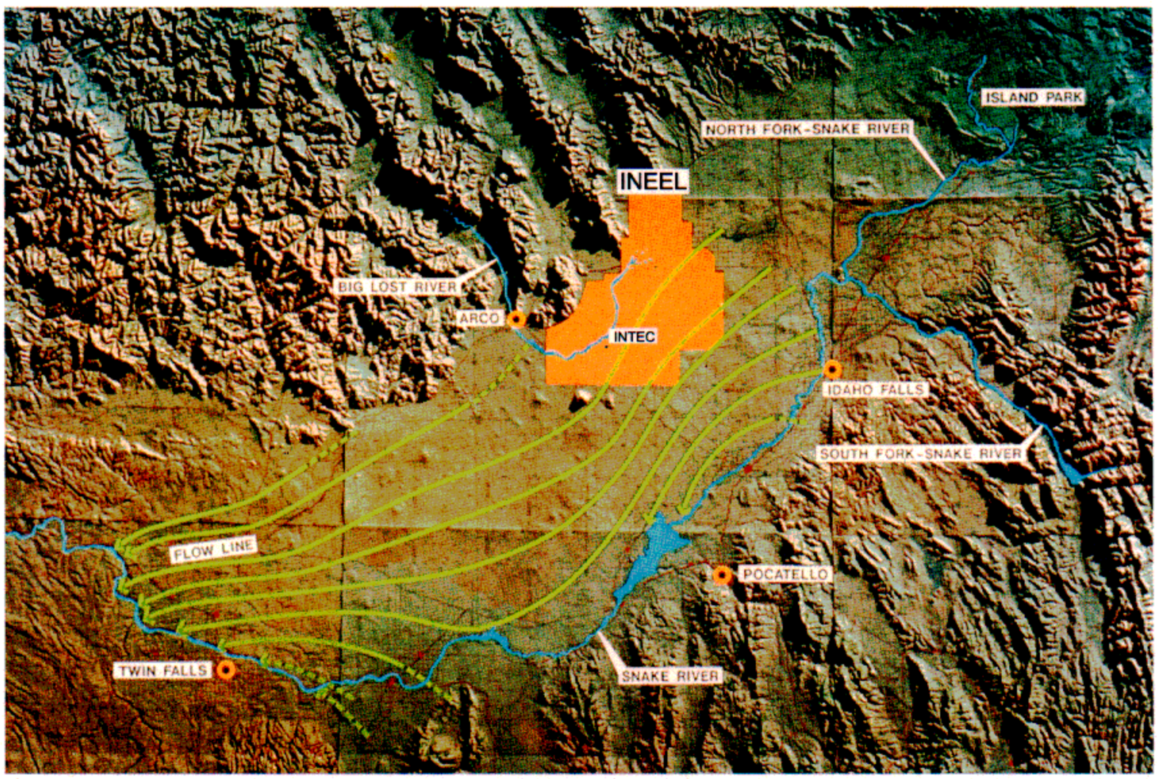

Figure 1-5. Map of the INEEL and the Eastern Snake River Plain with aquifer flow lines depicted in green.

shelter for leachate transfer equipment. One crest pad building, located on the northern side of the landfill, will be for the landfill; the other, located on the northern side of the evaporation pond, will be for the evaporation pond. Fencing will be maintained around the ICDF Complex to provide security of the components and control of the waste handling practices that take place. The proximity of the ICDF Complex to the INTEC facility allows for utilities to be extended to serve the SSSTF and the ICDF landfill and evaporation pond.

The land surface of the INEEL is relatively flat. The predominant relief on the INEEL is the result of volcanic buttes and unevenly surfaced and fissured basalt flows. Elevations on the INEEL range from 1,585 m (5,200 ft) in the northeast to 1,448 m (4,750 ft) in the southwest with the average being approximately 1,520 m (5,000 ft). INTEC is located on an alluvial plain approximately 61 m (200 ft) from the Big Lost River channel (near the channel intersection with Lincoln Boulevard in the south-central portion of the INEEL). Elevation at INTEC is 1,498 m (4,914 ft). Gravelly, medium-to-coarse textured soils derived from the alluvial deposits occur in the vicinity of INTEC. The underlying basalt is covered with as much as 15.2 m (50 ft) of these soils and the land surface is flat. The natural plant life is limited by soil type, meager rainfall, and extended drought periods and consists mainly of sagebrush and various grasses.

The INEEL is located in the Mud Lake-Lost River Basin (also known as the Pioneer Basin). This closed drainage basin includes three main streams: the Big and Little Lost Rivers and Birch Creek. The Big Lost River flows southeast from Mackay Dam, past Arco, and onto the Snake River Plain near the INEEL southwestern boundary. The Birch Creek and Little Lost River channels enter the INEEL from the northwest. These three streams drain the mountain areas to the north and west of INEEL, although most flow is diverted for irrigation in the summer months before it reaches the site boundaries. Flow that reaches the INEEL infiltrates the ground surface along the length of the streambeds, in the spreading areas behind the diversion dam at the southern end of the INEEL, and, if the stream flow is sufficient, in the ponding areas (playas or sinks) in the northern portion of the INEEL. During dry years, there is little or no surface water flow on the INEEL. Because the Mud Lake-Lost River Basin is a closed drainage basin, water does not flow off the INEEL but rather infiltrates the ground surface to recharge the aquifer, or is lost by evapotranspiration.

Existing man-made surface water features at INTEC consist of two percolation ponds that were used for disposal of water from the service waste system and which recently went off-line in August 2002, and sewage treatment lagoons and infiltration trenches for treated wastewater. INTEC also is surrounded by a stormwater drainage ditch system (DOE-ID 1998a). Stormwater run-off from most areas of INTEC flows through ditches to an abandoned gravel pit on the northeast side of INTEC. From the gravel pit, the run-off infiltrates the ground. The system is designed to handle a 25-year, 24-hour storm event. Because the land is relatively flat (slopes of generally less than 1%) and annual precipitation is low, stormwater run-off volumes are small and are generally spread over large areas where they may evaporate or infiltrate the ground surface.

The Snake River Plain has a relatively low rate of seismicity, whereas the surrounding Basin and Range has a fairly high rate of seismicity (WCFS 1996). The primary seismic hazards from earthquakes to INEEL facilities consist of the effects from ground shaking and surface deformation (surface faulting, tilting). Other potential seismic hazards such as avalanches, landslides, mudslides, and soil liquefaction are not likely to occur at the INEEL because the local geological conditions and terrain are not conducive to these types of hazards. Based on the seismic history and geologic conditions, earthquakes greater than moment magnitude of 5.5 and associated strong ground shaking and surface fault rupture are not likely to occur within the Snake River Plain (WCFS 1996). However, moderate to strong ground shaking could affect the INEEL from earthquakes in the Basin and Range Provence.

Volcanic hazards include the effects of lava flows, fissures, uplift, subsidence, volcanic earthquakes, and ash flows or airborne ash deposits. Most of the basalt volcanic activity occurred from 4 million to 2,100 years ago in the INEEL area. The most recent and closest volcanic eruption occurred at the Craters of the Moon National Monument, 43 km (26.8 mi) southwest of INTEC (Kuntz et al. 1992). Based on probability analysis of the volcanic history in and near the south-central INEEL area, the Volcanism Working Group (VWG) estimated that the conditional probability that basaltic volcanism would affect a south-central INEEL location is less than once per 100,000 years or longer (VWG 1990). The probability is associated primarily with the Axial Volcanic Zone and the Arco Volcanic Rift Zones. INTEC is located in a lesser lava flow hazard area of the INEEL, more than 8 km (5 mi) from the Axial Volcanic Zone and any volcanic vent younger than 400,000 years. The probability that basaltic volcanism would affect a south-central INEEL location is less than once per 400,000 years or longer.

1.2.3 Demography

Population growth surrounding the INEEL (i.e., within a seven-county region comprised of Bannock, Bingham, Bonneville, Butte, Clark, Jefferson, and Madison counties, and the Fort Hall Indian Reservation and Trust Lands) has paralleled statewide growth from 1960 to 1990. During this time, the regional population increased an average of approximately 1.3% annually, while the annual growth rate for the state was 1.4% (BEA 1997). From 1990 to 2000, state population growth accelerated to over 2.9% per year, and the regional population growth remained under 2% (DOC 1997a, 1997b). Population growth for both the state and regional populations are projected to slow after the year 2000. Table 1-1 lists 1990 and 2000 census data for the counties surrounding the INEEL, and growth projections for 2010 and 2025. The projections are based on an annual growth rate of 1.5%.

Bannock and Bonneville counties have the largest populations in the region and together account for almost 64% of the total regional population in the year 2000. Butte and Clark are the most sparsely populated counties and together contain less than 1% of the regional population. The largest cities in the region are Pocatello (Bannock County) and Idaho Falls (Bonneville County), with year 2000 populations of approximately 51,466 and 50,730, respectively (DOC 2001). The nearest populated area to the INEEL is Atomic City, population about 25, located approximately 1.6 km (1 mi) from the southern INEEL boundary and about 18 km (11 mi) from INTEC.

Table 1-1. Regional population data and projections of counties surrounding the INEEL, selected years 1990–2025.[a]

County	1990	2000[b]	2010	2025
Bannock	66,026	75,565	84,474	102,710
Bingham	37,583	41,735	48,016	58,382
Bonneville	72,207	82,522	92,902	112,958
Butte	2,918	2,899	3,631	4,415
Clark	762	1,022	985	1,198
Jefferson	16,543	19,155	21,609	26,274
Madison	23,674	27,467	27,733	33,720
Total	219,713	250,365	279,350	339,657

a. Source: DOC (1997a, b).

b. Source: DOC (2001).

No permanent residents live within an 18-km (11-mi) radius of INTEC on the INEEL. No cities or towns are within 16 km (10 mi) of the ICDF landfill. However, several INEEL facilities, such as Central Facilities Area (CFA), Test Reactor Area (TRA), and Radioactive Waste Management Complex (RWMC) are within 16 km (10 mi) of the ICDF landfill. Also, the Experimental Breeder Reactor I (EBR-I), a National Historic Landmark, is located southwest and within 16 km (10 mi) of the ICDF landfill.

Variations in populations are caused by the daily influx of the INEEL workforce. About 4,110 workers are employed within 16 km (10 mi) of INTEC. U.S. Highways 20 and 26 pass through the site and are within 16 km (10 mi) of INTEC. Traffic on these highways, other than the daily Site traffic, is related to travel between cities surrounding the Site and the many recreational opportunities in the area. INEEL employment projections indicate a stabilization of the job force at about 8,000 after FY 2000 (DOE 2002).

1.2.3.1 Uses of Adjacent Lands. The INEEL occupies approximately 2,305 km^2 (890 mi^2) of land in Bingham, Bonneville, Butte, Clark, and Jefferson counties in southeastern Idaho. Approximately 2% of this land (4,613 ha [11,400 ac]) has been developed to support INEEL facility and program operations associated with energy research and waste management activities (DOE 1995). INEEL operations are performed within the Site's primary facility areas (CFA, TRA, INTEC, etc.), which occupy 822 ha (2,032 ac). A 140,000-ha (345,000-ac) security and safety buffer zone is located around the core development area, which also accommodates environmental research and ecological and sociocultural preservation.

Approximately 6% of the INEEL (14,000 ha [34,000 ac]) is devoted to utility rights-of-way and public roads, including Highway 20 (which runs east and west and crosses the southern portion of the INEEL), Highway 26 (which runs southeast and northwest intersecting Highway 20), and Idaho State Highways 22, 28, and 33 (which cross the northeastern part of INEEL) (DOE 1995).

Up to 140,000 ha (340,000 ac) of the INEEL is leased for cattle and sheep grazing (DOE 1995); the Bureau of Land Management administers grazing permits. However, grazing of livestock is prohibited within one-half mile of any primary facility boundary and within 3.2 km (2 mi) of any nuclear facility. In addition, 400 ha (900 ac) located at the junction of Idaho State Highways 28 and 33 are used by the U.S. Sheep Experiment Station as a winter feedlot (DOE-ID 1996). Figure 1-4 shows land use in the vicinity of the INEEL.

On July 17, 1999, the Secretary of Energy and representatives of the U.S. Fish and Wildlife Service, Bureau of Land Management, and Idaho State Fish and Game Department designated 29,649 ha (73,263 ac) of the INEEL as the Sagebrush Steppe Ecosystem Reserve (DOE 1999). In 1995, the National Biological Service listed the ungrazed sagebrush steppe ecosystem in the Intermountain West and big sagebrush (*Artemisia tridentata*) in Idaho's Snake River Plain as critically endangered (Noss et al. 1995). The INEEL Sagebrush Steppe Ecosystem Reserve was designated to ensure this portion of the ecosystem receives special scientifically controlled consideration. Conservation management in this area is intended to maintain the current vegetation and provide the opportunity for study of an undisturbed sagebrush steppe ecosystem. Traditional rangeland uses, such as livestock grazing, which currently exist in a portion of the area, will be allowed to continue under this management designation. The designated INEEL Sagebrush Steppe Ecosystem Reserve is located in the northwest portion of the area. The southern boundary of the reserve, which runs east and west along section lines, is about 18 km (11 mi) north of INTEC at the closest point (DOE 2002).

Recreational uses of the INEEL include public tours of general facility areas and the EBR-I, a National Historic Landmark. Controlled hunting also is permitted on the INEEL but is restricted to one-half mile inside the Site boundary. These restricted hunts are intended to assist the Idaho Department of Fish and Game in reducing crop damage caused by wild game on adjacent private agricultural lands. The INEEL is designated as a National Environmental Research Park, functioning as a field laboratory set aside for ecological research and evaluation of the environmental impacts from nuclear energy development (DOE 1999).

The INEEL is located on federal land that is recognized as part of the Shoshone-Bannock Tribes aboriginal territory and contains cultural resources important to the tribes. Protection of these cultural resources, access to sacred sites, sites of traditional use, and repatriation of native American human remains and cultural items are of paramount importance to the tribes and DOE.

Land use at the INEEL is in a state of transition. Emphasis is moving toward nuclear energy research, radioactive and hazardous waste management, environmental restoration and remedial technologies, and technology transfer, resulting in more development of the INEEL within some facility areas and less development in others. DOE has projected land use scenarios at the INEEL for the next 25, 50, 75, and 100 years. Future development is projected to take place in the central portion of the INEEL within existing facility areas. For further review, see the *Long-Term Land Use Future Scenarios for the Idaho National Engineering Laboratory* (DOE-ID 1995) and the *Idaho National Engineering and Environmental Laboratory Comprehensive Facility & Land Use Plan* (DOE-ID 1996).

Approximately 75% of the land adjacent to the INEEL is owned by the federal government and administered by the Bureau of Land Management. Land uses on this federally held land consist of wildlife management, mineral and energy production, grazing, and recreation. The State of Idaho owns approximately 1% of the adjacent land. This land is also used for wildlife management, grazing, and recreation. The remaining 24% of the land adjacent to the INEEL is privately owned and is primarily used for grazing and crop production (SAR-II-8.4).

Small communities and towns located near the INEEL boundaries include Mud Lake and Terreton to the east; Arco, Butte City, and Howe to the west; and Atomic City to the south. The larger communities of Idaho Falls/Ammon, Rexburg, Blackfoot, and Pocatello/Chubbuck are located to the east and southeast of the INEEL site. The Fort Hall Indian Reservation is located southeast of the INEEL Site.

All county plans and policies encourage development adjacent to previously developed areas to minimize the need to extend infrastructure improvements and to avoid urban sprawl. Because the INEEL is remotely located from most developed areas, INEEL lands and adjacent areas are not likely to experience residential and commercial development, and no new development is planned near the INEEL Site. However, recreational and agricultural uses are expected to increase in the surrounding area in response to greater demand for recreational areas and the conversion of rangeland to cropland (DOE-ID 1993a).

The four most prominent tourist/recreation areas or attractions in the INEEL area include

- Yellowstone National Park, which is approximately 117 km (72.5 mi) northeast of the INEEL, and 160 km (99.5 mi) from INTEC
- EBR-I, which is situated on the INEEL
- Craters of the Moon National Monument, which is located approximately 30 km (19 mi) southwest of the INEEL

- The resort areas of Ketchum and Sun Valley, which are approximately 95.8 km (59.5 mi) west of the INEEL, and 115.9 km (72 mi) from INTEC (SAR-II-8.4).

Other recreation and tourist attractions in the region surrounding the INEEL site include Hell's Half Acre Wilderness Study Area, Black Canyon Wilderness Study Area, Camas National Wildlife Refuge, Market Lake State Wildlife Management Area, North Lake State Wildlife Management Area, Targhee and Challis National Forests, Sawtooth National Recreation Area, Sawtooth Wilderness Area, Sawtooth National Forest, Grand Teton National Park, Jackson Hole recreation complex, and the Snake River.

Planning assumptions in the *INEEL Comprehensive Facility & Land Use Plan* (DOE-ID 1996) are that the INEEL will remain under government control for at least the next 100 years. Future government management and control becomes increasingly uncertain with time. No residential development will be allowed to occur within INEEL boundaries during the next 100 years.

INTEC was one of the facilities that had a future use scenario projected in the *Long-Term Land Use Future Scenarios for the Idaho National Engineering Laboratory* (DOE-ID 1995). The scenarios are broken down into the present situation, as well as for the next 25, 50, 75, and 100 years:

- Present: Interim storage of spent nuclear fuels, disposition of fuels, managing waste and improving waste, and water management techniques

- 25-year: Continue use as industrial area, planned new waste treatment facility

- 50-year: Approaching end of useful life if no new mission identified, decontamination and decommissioning with all or selected areas for restricted industrial use

- 75-year: Standby mode for restricted industrial use, reuse permitted but no new development outside existing fence line

- 100-year: Continuation as a restricted industrial area

- Implement institutional controls (to include a DOE-ID directive limiting access) to prevent perched water use while INTEC operations continue and to prevent future drilling into or through the perched zone (through noticing this restriction to local county governments, ShoBan Tribal Council, General Services Administration, BLM, and other agencies as necessary).

1.2.4 Meteorology

Meteorological data have been collected periodically at over 45 locations on and near the INEEL since 1949. The longest and most complete record of air temperature and precipitation observations (over 35 years) at the INEEL was collected from the weather station at CFA. The CFA station is located approximately 5 km (3 mi) south of INTEC. Differences in climate between the CFA monitoring station and INTEC are minimal. INTEC and CFA are at approximately the same terrain elevation and have the same exposure to wind, snow, and cloud cover.

The National Oceanic and Atmospheric Administration Air Resources Laboratory conducts most of the meteorological monitoring within 80 km (50 mi) of the INEEL. An overview of climatological data is available from data summaries collected from the CFA monitoring station. A summary of the climatology of the INEEL is available in *Climatography of the Idaho National Engineering Laboratory* (Clawson et al. 1989).

1.2.4.1 Temperature. Temperatures at the INEEL vary widely over the course of the year. Records for CFA indicate that the highest and lowest daily temperatures range from 38°C (101°F) to -44°C (-47°F), respectively. The average annual temperature at the INEEL exhibits a gradual 7-month increase, beginning with the first week in January and continuing through the third week in July. During the months of April through October, the average monthly temperature varies from 5 to 20°C (41 to 68°F). The temperature then decreases over the course of 5 months until the minimum average temperature is again reached in January. During the months of November through March, the average monthly temperature varies from -9 to -l°C (15 to 30°F). On average, 42% of the days in a year contain a freeze/thaw cycle, in which the maximum air temperature exceeds 0°C (32°F), and the minimum air temperature is at or below 0°C (32°F). Inversion conditions (warmer air temperature with increasing altitude) and lapse conditions (cooler air temperature with increasing altitude) occur approximately 46% and 54% of the time, respectively.

1.2.4.2 Wind. The prevailing wind direction at INTEC and at most locations on the INEEL is southwesterly. In summer, a very sharp reversal in wind direction occurs daily; winds from the southwest predominate during daylight hours, and northeasterly winds predominate at night. The reversals normally occur shortly after sunrise and sunset. The average wind speed at the 6-m (20-ft) level at CFA ranges from 8.2 km/h (5.1 mph) in December to 15 km/h (9.3 mph) in March and April. The highest hourly-average wind speed at the 6-m (20-ft) level was 108 km/h (67 mph), and the maximum instantaneous gust at the same level was 125.5 km/h (78 mph). Strong wind gusts can occur in the immediate vicinity of thunderstorms. On the average, these gusts occur 2 or 3 days per month during June, July, and August. Calm conditions prevail 11% of the time.

1.2.4.3 Precipitation. The average annual precipitation at CFA is 22 cm (8.7 in.). The highest recorded annual amount of precipitation recorded was 36.6 cm (14.4 in.) in 1963, and the lowest amount was 11.4 cm (4.5 in.) in 1966. The majority of precipitation occurs in May and June, with an average precipitation for each of these months of 3 cm (1.2 in.). Precipitation amounts in excess of 2.54 cm (1 in.) per day have been recorded eight times at CFA, with the maximum being 4 cm (1.64 in.). The maximum hourly precipitation observed at CFA is 1.37 cm (0.54 in.). Snowfall is a substantial contributor to total annual precipitation and ranges from 17 to 152 cm/yr (6.7 to 60 in./yr), with an annual average of 70 cm (28 in.). The maximum average monthly snowfall is 16.3 cm (6.4 in.), occurring in December.

1.2.4.4 Evaporation. The potential annual evaporation from a saturated ground surface at the INEEL is approximately 91 cm (36 in.), with 80% of the evaporation occurring between May and October. During July, the warmest month of the year, the daily potential evaporation rate is approximately 0.6 cm (0.2 in.) (Hull 1989). Evaporation occurring during the remainder of the year is small. Actual evaporation rates are much lower than potential rates because the ground surface is rarely saturated. Transpiration by the native vegetation of the Snake River Plain is estimated at 15 to 23 cm/yr (5.9 to 9.1 in./yr). From late winter to spring, precipitation is most likely to infiltrate into the ground because of the low evapotranspiration rates (Mundorff et al. 1964). For evaporation from surface water bodies (ponds), a pan evaporation rate of approximately 109 cm/yr (43 in./yr) has been estimated (Clawson et al. 1989).

1.2.4.5 Relative Humidity. The highest relative humidity is observed in the winter, with the average midday relative humidity at about 55%. The lowest is observed in the summer, when the midday average is approximately 18%. An absolute maximum relative humidity value of 100% was observed in every month of the year except July, and the lowest observed was 4% in July and August. This is indicative of the very dry summers experienced at the INEEL.

1.2.4.6 Special Phenomena. Several other types of meteorological phenomena such as thunderstorms, hail, and tornadoes occur at the INEEL. The INEEL may experience an average of two to three thunderstorm days during each of the summer months from June through August with considerable year-to-year variation. Thunderstorms over the INEEL are usually much less severe than what is normally experienced in the mountains surrounding the Eastern Snake River Plain (ESRP) or areas of the Rocky Mountains. Precipitation from many thunderstorms evaporates before reaching the ground (virga). The frequent result is little or no measurable precipitation. Occasionally, however, rain amounts exceeding the long-term average may result from a single thunderstorm. Small hail has been observed to occasionally occur in conjunction with thunderstorms. The size of the hail is usually smaller than 0.1 cm (0.25 in) in diameter. The diameter may range up to 0.3 cm (0.75 in.) on very rare occasions. No hail damage has ever been reported at the INEEL.

Most tornado activity in the U.S. occurs east of the Rocky Mountains. In Idaho, tornadoes have been reported only in the spring and summer seasons (April through August). Records from 1950 through 1989 indicate a total of five funnel clouds and no tornadoes sighted within the boundaries of the INEEL. The chance of a tornado developing at the INEEL is extremely remote.

1.2.5 Geology

The INEEL is located on the west-central part of the ESRP, a northeast-trending structural basin about 322 km (200 mi) long and 80 to 112 km (50 to 70 mi) wide (Figure 1-6). The INEEL is underlain by a sequence of Tertiary and Quaternary volcanic rocks and sedimentary interbeds that are more than 3,048 m (10,000 ft) thick (Whitehead 1992). The volcanic rocks consist mainly of basalt flows in the upper part of the sequence and rhyolitic ash-flow tuffs in the lower part. Basalt and interbeds generally range in age from about 200,000 to 4 million years before present (Anderson et al. 1997), and underlie the plain to depths ranging from about 670 m to 1,158 m (2,200 to 3,800 ft) below land surface.

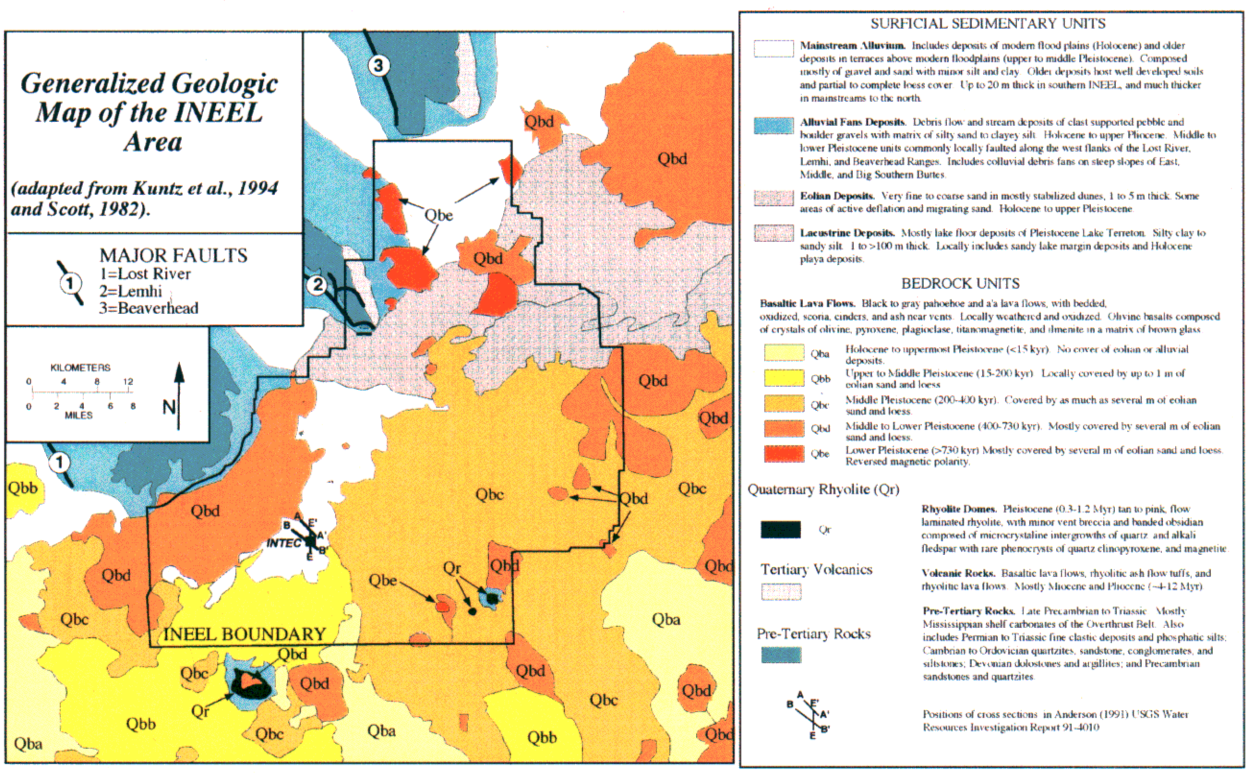

Figure 1-6. Generalized geological map of the INEEL area.

Hundreds of basalt flows, basalt-flow groups, and sedimentary interbeds underlie the INEEL. Basalt makes up about 85% of the volume of deposits in most areas. A basalt flow is a solidified body of rock formed by the surficial outpouring of molten lava from a vent or fissure (Bates and Jackson 1980). A basalt-flow group consists of one or more distinct basalt flows deposited during a single, brief eruptive event. All basalt flows of a group erupted from the same vent or several nearby vents; represent the accumulation of one or more lava flows from the same magma; and have similar geologic ages, paleomagnetic properties, potassium contents, and natural-gamma emissions (Anderson and Bartholomay 1995). The basalt flows consist mainly of medium- to dark-gray vesicular to dense olivine basalt. Individual flows generally range from 3 to 15 m (10 to 50 ft) thick and are locally interbedded with scoria and thin layers of sediment. Sedimentary interbeds are as thick as 15 m (50 ft) and consist of well-sorted to poorly sorted deposits of clay, silt, sand, and gravel. In places, the interbeds contain or consist mainly of scoria and basalt rubble. Sedimentary interbeds accumulated on the ancestral land surface for hundreds to hundreds of thousands of years during periods of volcanic quiescence and are thickest between basalt-flow groups.

At least 178 basalt-flow groups and 103 sedimentary interbeds underlie the INEEL above the effective base of the aquifer (Anderson et al. 1996a, 1997). Basalt-flow groups and sedimentary interbeds are informally referred to as A through S5. Basalt-flow groups A through L and related sediments range in age from about 200,000–800,000 years and make up the unsaturated zone and the uppermost part of the aquifer in most areas of the INEEL. Most wells in the southern and eastern parts of the INEEL are completed in basalt-flow groups AB through I and the related sediments. Flow groups AB through I and related sediments range in age from about 200,000–640,000 years and make up a stratigraphic section characterized by horizontal to slightly inclined layers. Anderson et al. (1997) estimated the geologic ages of basalts and sediments in the unsaturated zone and the SRPA from about 200,000–1,800,000 years; average accumulation rates are reflective of a subsidence rate of 50 m (164 ft) 100,000 year.

The nomenclature for the stratigraphy underlying the INTEC facility and the surrounding area is based on work presented by Anderson (1991) and Anderson et al. (1996a). A north-south geologic cross section, illustrated in Figure 1-7, shows the complexity of the subsurface at INTEC.

The stratigraphy of the aquifer at and near INTEC is dominated by thick, massive basalt flows of flow group I and thin, overlying flows of flow groups B through H. Significant changes in the flow thickness are often related to changes in the lithology of the flow or are caused by the flow margins in which the flow appears as a lobe of basalt. The lithologic changes that may cause a change in the flow thickness are the existence of pyroclastic deposits on or within a flow, or a flow being very vesicular, and thus, more susceptible to the effects of erosion.

Based on the Anderson (1991) geologic cross section, the unsaturated zone and upper regional aquifer underlying INTEC are comprised of 19 basalt-flow groups, 11 sedimentary interbeds, and surficial alluvium. The sediments, as interpreted, appear to be primarily made up of sands and silts with some small clay lenses. The majority of the sediments are thin 0.3- to 1.5-m (1- to 5-ft) layers of silt between the major basalt flows. Sediments were most likely deposited in eolian or fluvial type environments. Two major sediment sequences are shown on the cross sections: the upper sequence associated with the "CD," thick "D," and "DE2" sands and silts; and the lower sediments associated with the "DE6," "DE7," and "DE8" stratigraphic units.

The cross sections show a very thick sequence of sediments, particularly in the northern end of the south-north section, which are stratigraphically shown as the "CD," "D," and "DE2" units. These sediments appear to be a thick sequence of sands over silts and clays. The sediments associated with the "DE6," "DE7," and "DE8" stratigraphic units appear to be made up of gravels, silts, and clays. These sediments were most likely deposited in a fluvial environment and may indicate a braided stream deposit.

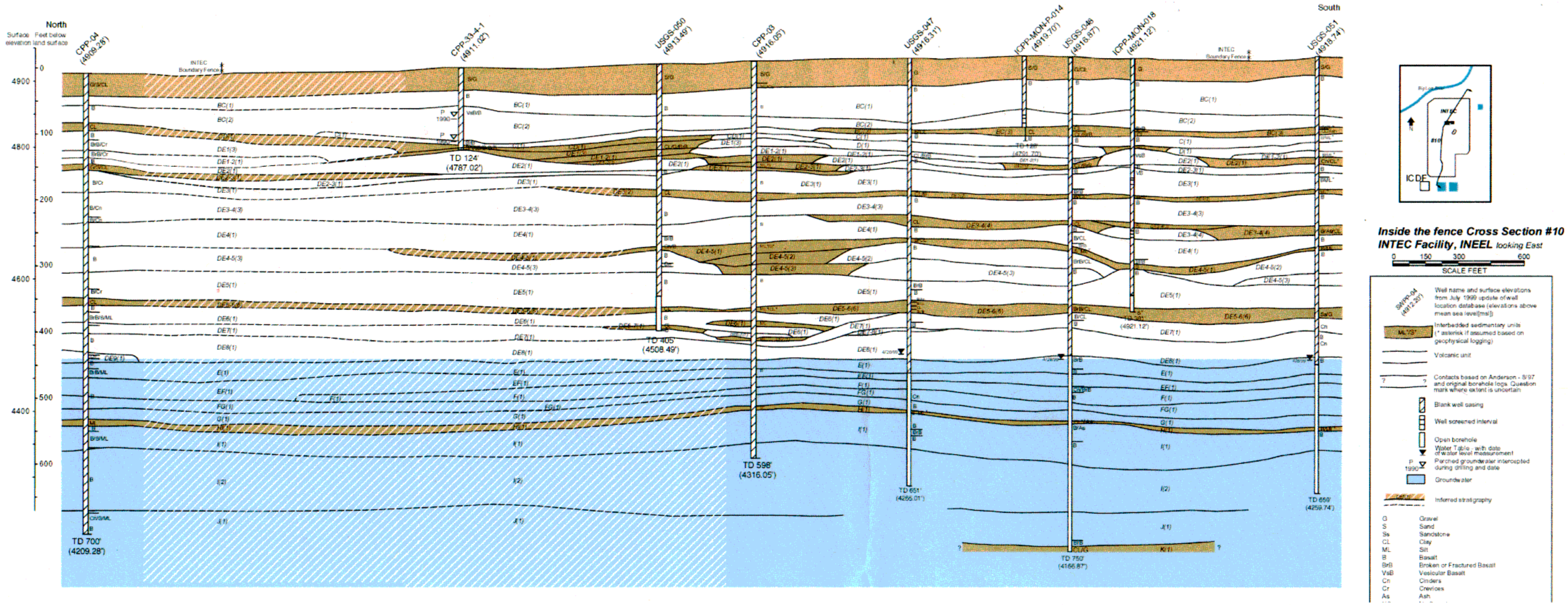

Figure 1-7. North-south geological cross section at INTEC.

The geology beneath the ICDF Complex has been characterized from information gathered from logs (lithologic, geophysical, and video) as well as tests (geotechnical and hydrologic) from the drilling of numerous SRPA and perched water wells and coreholes located in the vicinity of the ICDF Complex and INTEC. The locations of wells closest to the ICDF Complex are shown in Figure 1-8. An east-west geologic cross section through the ICDF Complex (A-A' in Figure 1-8) is shown in Figure 1-9.

The subsurface beneath the ICDF Complex, as shown in Figure 1-9, is characterized by approximately 9 to 16.8 m (30 to 55 ft) of alluvial materials underlain by a series of basalt flows and discontinuous sedimentary interbeds. The surface alluvium at the ICDF Complex has been mapped as a flood delta or fan related to late Pleistocene cataclysmic flooding, most likely from the Pinedale Glaciation (Rathburn 1991). The Pinedale Glaciation occurred between 12,000 and 35,000 years ago. An intermittent layer of fine sand, silt, and clay known as "old alluvium" in the literature (designation SM to CL) ranges in thickness from 0 to 4 m (0 to 13 ft) and occurs at the top of basalt. The thickness correlates to low spots and depressions and tends to increase to the south and west of the ICDF Complex. It is less prevalent in the northwest area. Sand lenses were periodically found within this layer. The sediments overlie vesicular dark gray, olivine basalt bedrock that may be weathered and fractured in the first several feet near the interface (DOE-ID 2000a).

As can be seen in Figure 1-9, two very distinctive massive basalt flows can be used as marker beds and traced between most boreholes underneath the ICDF Complex. The depth at which these distinctive flows occur varies between boreholes. The CD basalt flow occurs at a depth between approximately 41 to 53 m (135 and 175 ft), and the DE5 basalt occurs at a depth between approximately 98 and 120 m (320 and 395 ft) in USGS-57. The CD basalt flow is characterized by a higher-than-average natural-gamma count. Above the CD basalt flow is a fairly continuous series of thin interbeds interspersed with thin basalt flows. This is the most continuous interbed underlying the ICDF Complex and is the location of perched water that forms intermittently in response to wastewater discharges to the percolation ponds. As can be seen in Figure 1-9, the other interbeds are discontinuous, less massive, and cannot be traced horizontally between boreholes. The DE5 basalt is among the thickest and most massive of the basalt flows found in the subsurface underlying the ICDF Complex and has a typical thickness of nearly 30 m (100 ft).

Well USGS-51 is completed in the SRPA and is just east of the ICDF Complex, between the ICDF Complex and the west percolation pond. In this well, there are at least six sedimentary interbeds and 13 basalt flow groups. Narrow interbeds ranging from 1.2 to 4.5 m (4 to 15 ft) thick are interspersed with basalt flow groups ranging from 2.4 to 29 m (8 to 96 ft) thick (Anderson 1991).

Holocene surficial geology and archaeology suggest that fluvial and eolian deposition and tectonic subsidence in the INEEL area have been in approximate net balance for at least the past 10,000 years. A reversal of the long-term, regional pattern of ESRP subsidence, sedimentation, and volcanism into an erosional rather than a depositional regime would require major changes from the Holocene tectonic or climatic configuration of the ESRP. Worldwide geologic evidence indicates that the Quaternary epoch (approximately the past 2 million years) has been a time of major climatic fluctuations. During colder and wetter periods, glaciers occupied high-elevation areas. Lowland areas such as the ESRP received thick, widespread loess blankets. Lowland areas also were periodically impacted by local catastrophes (such as the large, late-Pleistocene, glacial outburst flood[s] that traveled down the Big Lost River valley), eroded upland surfaces on the ESRP, and deposited sediment in the INTEC area. If the future ESRP climate were to become warmer and more arid, the probable consequences would be decreased vegetation and increased eolian transport of fine-grained sediment, mainly as longitudinal dunes of fine sand.

Future climate fluctuations on the ESRP, to either colder/wetter or warmer/drier conditions, are not expected to erode the INTEC land surface. Quaternary geologic and Holocene archaeological data suggest

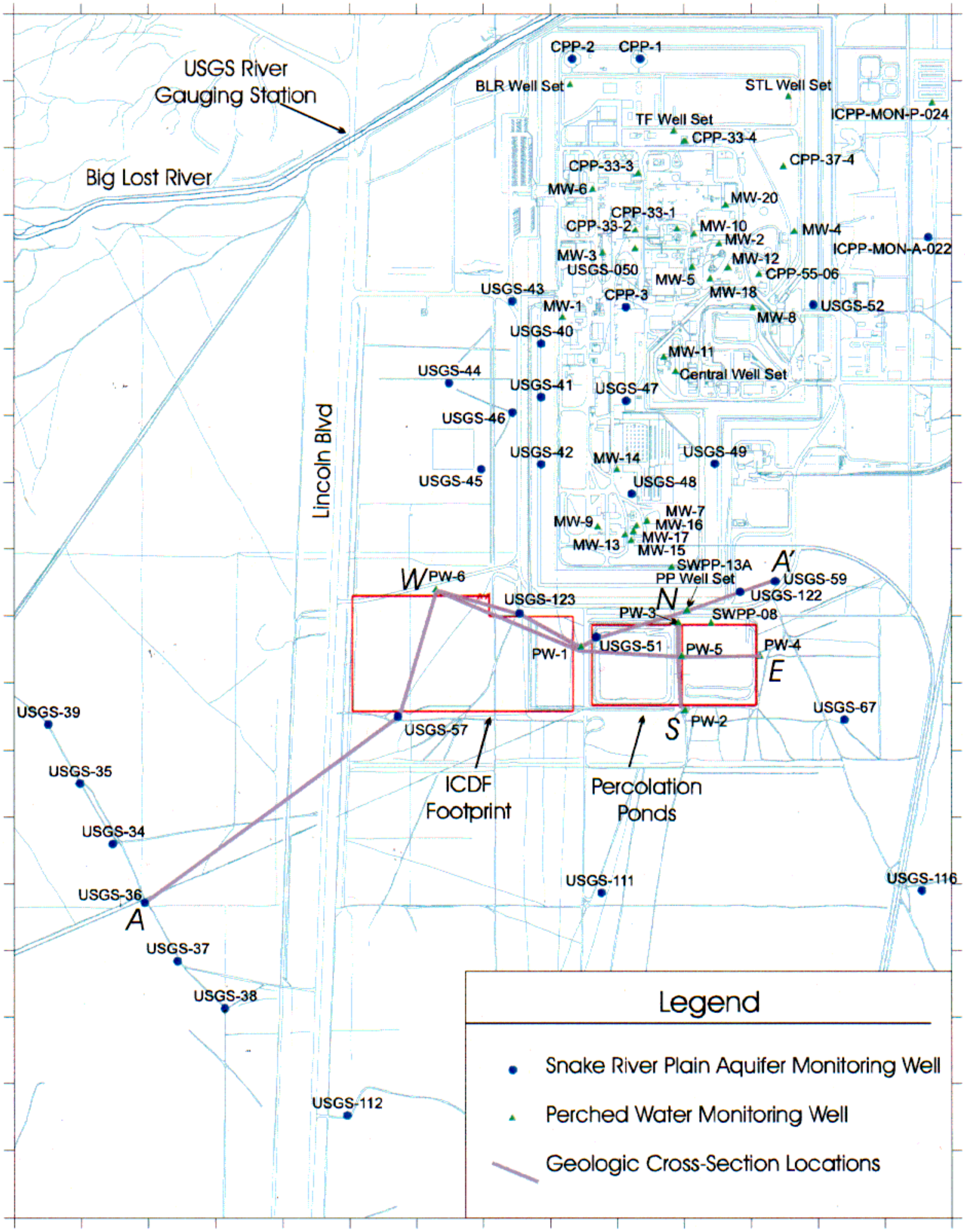

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Figure 1-8. Locations of geologic cross-sections and existing wells at INTEC.

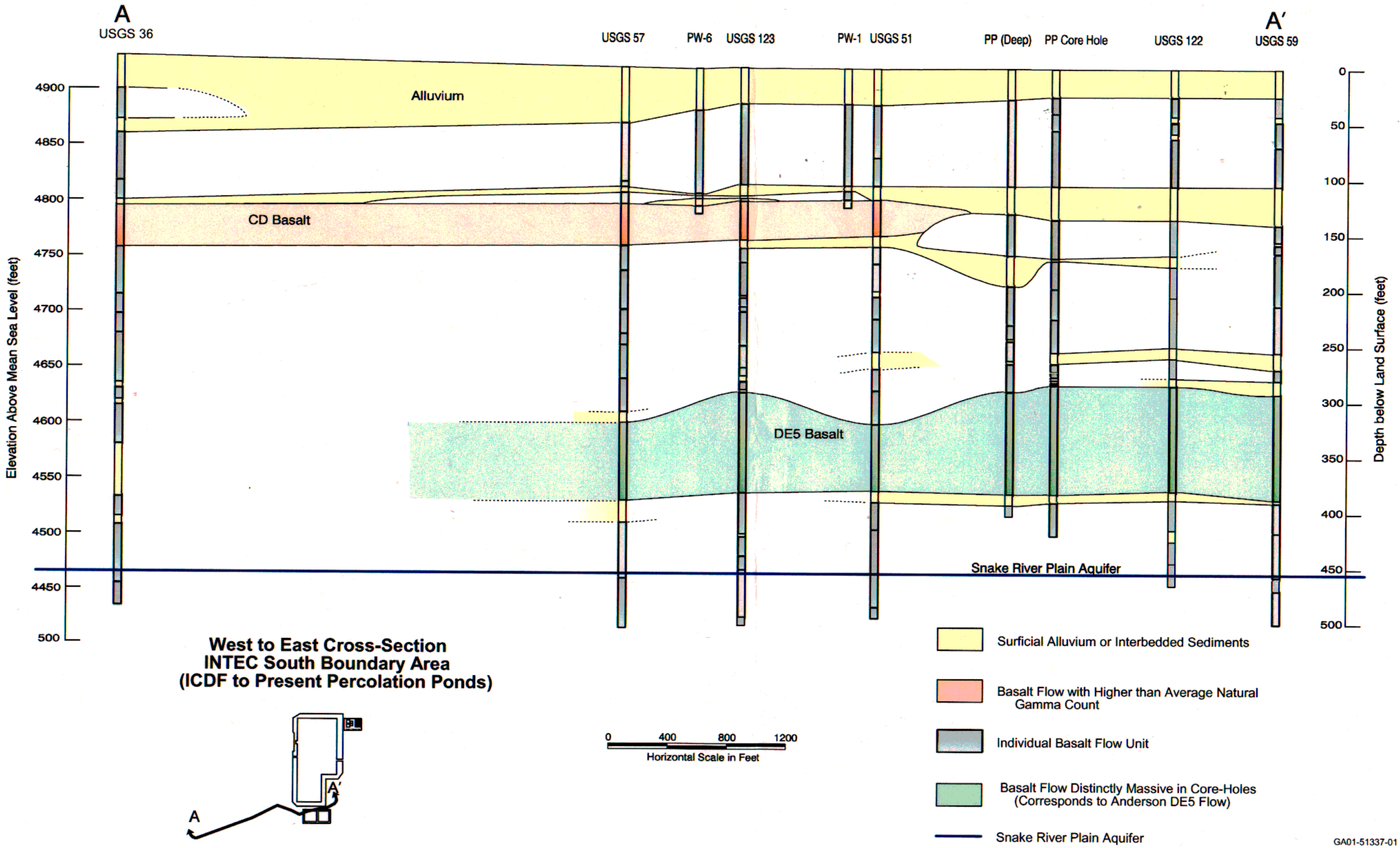

Figure 1-9. An east-west geologic cross section through the ICDF.

the INEEL area will probably continue its long-term history of regional subsidence and net accumulation of sedimentary and volcanic materials, although sedimentation patterns on the ESRP will change in response to future climate fluctuations.

Surface soil erosion at INTEC could occur as a consequence of faulting and uplift, but this erosion would involve a major change in the Quaternary tectonic configuration of the ESRP. Therefore, this scenario is improbable within the next 10,000 years, considering

- The regional seismicity and tectonic history of the INEEL area
- The absence of Quaternary tectonic faults on the ESRP in the vicinity of the INTEC
- The long response time for significant erosion to occur as a result of protracted faulting and uplift.

In summary, the following impacts from volcanic and tectonic activity are relevant to INTEC radiological performance assessment:

- During the past 4 million years, the ESRP and the INTEC area have undergone regional subsidence, basaltic volcanism, and fluvial and eolian sedimentation. Erosion has not been a significant process on the ESRP.
- Surficial- and subsurface-geologic data indicate that the INTEC area has both subsided and accumulated basalt lava flows and sediments at an average rate of 0.3 mm (0.01 in.)/year. Significant uplift or erosion has not interrupted this long-term trend.
- Lava inundation or magma intrusion associated with volcanism from the nearby Arco Volcanic Rift Zone is improbable considering the volcanic history of the area. Lava inundation or magma intrusion would not likely result in the release of radionuclides to the environment.

1.2.6 Groundwater Hydrology

The Snake River Plain Aquifer (SRPA), one of the largest and most productive groundwater resources in the United States, underlies the INEEL. The aquifer is listed as a Class I aquifer, and the EPA has designated it as a sole source aquifer. The SRPA consists of a series of saturated basalt flows and interlayered pyroclastic and sedimentary materials that underlie the ESRP. The SRPA is approximately 322 km (200 mi) long, 64 to 97 km (40 to 60 mi) wide, and covers an area of 24,853 km^2 (9,600 mi^2). It extends from Bliss, Idaho, on the southwest to near Ashton, Idaho, northeast of the INEEL. Aquifer boundaries are formed by contacts with less permeable rocks at the margins of the plain (Mundorff et al. 1964).

Permeability of the aquifer is controlled by the distribution of highly fractured basalt flow tops and interflow zones with some additional permeability contributed by vesicles and intergranular pore spaces. The variety and degree of interconnected water-bearing zones complicates the direction of groundwater movement locally throughout the aquifer (Barraclough et al. 1981). Although a single lava flow may not be a good aquifer, a series of flows may include several excellent water-bearing zones. If the sequence of basalt flows beneath the Snake River Plain is considered to constitute a single aquifer, it is one of the world's most productive (Mundorff et al. 1964).

Robertson et al. (1974) estimated that as much as 2 billion acre-ft of water may be in storage in the aquifer, of which about 500 million acre-ft are recoverable. The aquifer discharges about 7.6 million acre-ft of water annually to springs and rivers. Pumpage from the aquifer for irrigation totals about 1.9 million acre-ft annually (Hackett et al. 1986). Groundwater withdrawn from wells and springs supplies 100% of the drinking water consumed within the ESRP.

Recharge to the aquifer occurs mostly through infiltration of irrigation water (5.1 million acre-ft) and from valley underflow (1.5 million acre-ft) from the 90,610 km^2 (35,000 mi^2) of recharge area in the surrounding mountains to the north and northeast of the plain (Hackett et al. 1986). Recharge from river seepage amounts to about 1.3 million acre-ft, and direct recharge from precipitation falling on the plain is estimated at 0.8 million acre-ft (Hackett et al. 1986).

The U.S. Geological Survey (USGS) has maintained a groundwater monitoring network at the INEEL to characterize the occurrence, movement, and quality of water and to delineate the movement of facility-related wastes in the SRPA since 1949. This network consists of a series of wells from which periodic water-level and water-quality data are obtained. In addition to the independent USGS groundwater monitoring, the INTEC implemented a groundwater monitoring program in October 1991 of selected wells in fulfillment of the RCRA and DOE O 231.1 groundwater monitoring requirements.

In the vicinity of INTEC, 16 aquifer tests resulted in transmissivity estimates ranging five orders of magnitude from a maximum transmissivity of 7.0×10^4 m^2/day (7.5×10^5 ft^2/day) at Well CPP-3 (the former INTEC injection well) to a minimum transmissivity of 0.93 m^2/day (10 ft^2/day) at Well USGS-114 (Ackerman 1991). Based on the transmissivity testing, the average hydraulic conductivity of the SRPA basalts at INTEC was estimated by Ackerman to be approximately $4.0 \times 10^2 \pm 7.9 \times 10^2$ m/day ($1.3 \times 10^3 \pm 2.6 \times 10^3$ ft/day). The standard deviation of the basalt hydraulic conductivity measurements is larger than the mean because the range of the observed values is five orders of magnitude. Using the average hydraulic conductivity, a hydraulic gradient of 1.2 m/km (6.3 ft/mi) at INTEC, and an estimated effective porosity of 10%, the calculated seepage velocity in the vicinity of the INTEC is approximately 3 m/day (10 ft/day). The hydraulic gradient in the SRPA around INTEC is very flat and flow is generally south-southwest.

1.2.7 Surface Water Hydrology

Natural surface water near or on the INEEL consists mainly of three streams draining intermountain valleys to the north and northwest of the Site: the Big Lost River, the Little Lost River, and Birch Creek (Figure 1-10). Stream flows are often depleted before reaching the INEEL by irrigation and hydropower diversions and infiltration losses along the channel bed. When water does flow onto the INEEL, it either evaporates or infiltrates into the ground because the Pioneer Basin in which these streams terminate is a closed topographic depression on the Eastern Snake River Plain.

Stream flows from the Little Lost River and Birch Creek very seldom reach the INEEL. The Little Lost River drains the slopes of the Lemhi and Lost River mountain ranges. Water in the Little Lost River is diverted for irrigation north of Howe, Idaho, and does not flow onto the INEEL. The Little Lost River is considered to have negligible potential for flooding on the INEEL (Kjelstrom and Berenbrock 1996). Birch Creek originates from springs below Gilmore Summit in the Beaverhead Mountains and flows in a southeasterly direction onto the Snake River Plain. The water in the creek is diverted north of the INEEL for irrigation and hydropower purposes. In the winter months when the water is not used for irrigation, typically November through April, flows from Birch Creek are returned to an anthropogenic channel on the INEEL, 6.4 km (4 mi) north of TAN, and recharge the SRPA by infiltration.

The Big Lost River is the major surface water feature on the INEEL and at its closest point is roughly 60 m (200 ft) from the northwest facility boundary of INTEC and about 1 km (0.6 mi) from the ICDF landfill location. Major control on the Big Lost River upstream of the INTEC site includes the Mackay Dam and the INEEL diversion dam. The Big Lost River waters are impounded and regulated by

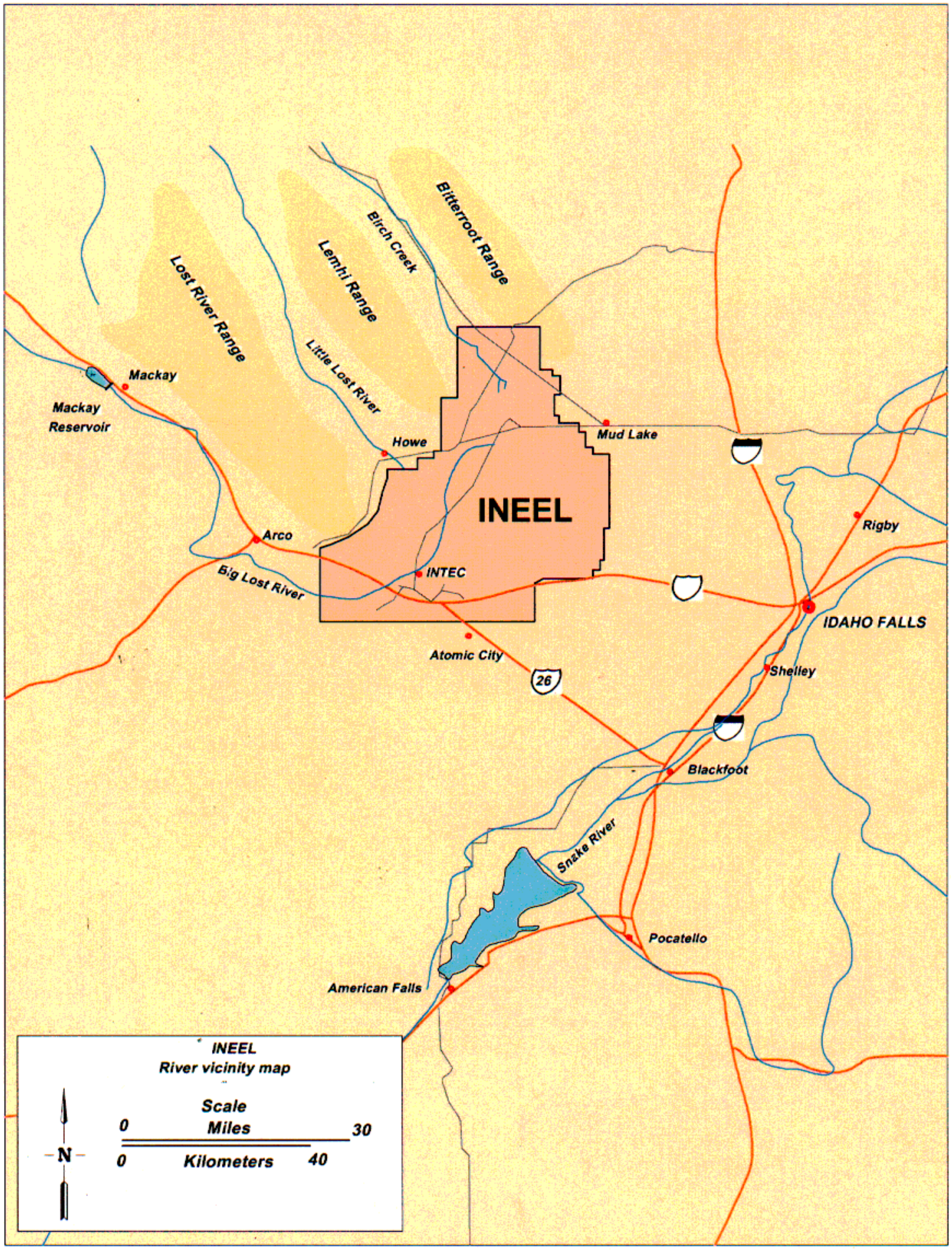

Figure 1-10. Surface water features on the INEEL.

Mackay Dam, located approximately 6.4 km (4 mi) northwest of Mackay, Idaho, for irrigation purposes downstream. The Big Lost River flows from the dam southeastward through the Big Lost River valley, past Arco and onto the ESRP. Stream flows are often depleted before reaching the INEEL by irrigation diversions and infiltration losses along the river. When flow in the Big Lost River actually reaches the INEEL, it is either diverted at the INEEL diversion dam or flows northward across the INEEL in a shallow, gravel-filled channel. The main channel branches into several channels 29 km (18 mi) northeast of the INEEL diversion dam, referred to as the Big Lost River Sinks, and terminates in a series of three shallow playas that are connected by branching channels. All flow of the Big Lost River that enters onto the INEEL, except for evapotranspiration losses, is recharged to the subsurface. The stretch of the Big Lost River on the INEEL is ephemeral with no recreational or consumptive uses (e.g., irrigation, manufacturing, or drinking) of the water. In addition, there are no identified future uses of surface water that may enter onto the INEEL.

The need for flood control on the INEEL was first recognized in the early 1950s when downstream facilities were threatened by localized flooding as a result of ice jams in the Big Lost River. The INEEL diversion dam was constructed in 1958 and enlarged in 1984 to divert high run-off flows from downstream INEEL facilities. The diversion dam consists of a small earthen diversion dam and headgate that diverts water from the main channel, through a connecting channel, and into a series of four natural depressions, called spreading areas. Gates placed on two large, corrugated steel culverts, which are 1.8 m (6 ft) in diameter, control flow downstream onto the INEEL. When the gates are wide open, the maximum flow through the diversion dam downstream onto the INEEL is 900 ft^3/sec (cfs) (Lamke 1969). Flow in the diversion channel is uncontrolled at discharges that exceed the capacity of the culverts. The diversion channel is capable of carrying 7,200 cfs from the Big Lost River channel into the spreading areas. Two low swales located southwest of the main channel will carry an additional 2,100 cfs for a combined diversion capacity of 9,300 cfs (Bennett 1986). The capacity of the spreading areas is 58,000 acre-ft at an elevation of 5,050 ft (McKinney 1985). An overflow weir in Spreading Area D allows water to drain southwest off the INEEL. Run-off from the Big Lost River has never been sufficient to exceed the capacity of the spreading area and overflow the weir.

1.2.7.1 Big Lost River 100-Year Flood Plain. The ICDF landfill is located outside the 100-yr flood plain of the Big Lost River. A USGS flood plain study (Berenbrock and Kjelstrom 1998) routed the 100-year peak flow estimate of 7,200 cfs (Kjelstrom and Berenbrock 1996) downstream onto the INEEL. The flood-routing study did not include the INEEL diversion dam in the model simulation. The study assumes 1,000 cfs of the peak flow will flow down the diversion channel and the remainder flow of 6,200 cfs is routed downstream onto the INEEL. The study uses a one-dimensional code that does not account for infiltration side or overbank losses. This conservative flood plain study indicates a potential for flooding in the north end of INTEC. All other INEEL facilities including the ICDF landfill are located outside of the Big Lost River 100-year flood plain. The extent of flooding in the northern portion of INTEC would reach a peak elevation of 1,497 m (4,911.6 ft) (Berenbrock and Kjelstrom 1998). The ICDF landfill site location at an average elevation of 1,500 m (4,922 ft) and about 1 km (0.6 mi) south of the Big Lost River is located outside of the Big Lost River 100-year flood plain. A recent evaluation of the INTEC geomorphic setting (based on soil profiles taken along the Big Lost River and used to develop a late Quaternary soil chronosequence) indicates that INTEC is sited on geomorphic surfaces that are well in excess of 10,000 years in age. This evaluation suggests that the hazard of significant flooding of this area by the Big Lost River is low under natural channel conditions (Ostenaa et al. 1999).

1.2.7.2 Run-on/Run-off from 25-year, 24-hour Storm Event. A statistical analysis of meteorological data from CFA for the period 1950 through 1995 estimates 4.3 cm (1.7 in.) of precipitation for a 25-year, 24-hour storm event and 5.6 cm (2.2 in.) of precipitation for a 100-year, 24-hour storm event (Sagendorf 1996). A hydrological evaluation of the internal and external drainage systems at INTEC was performed to determine if it is adequate for handling run-on/run-off from a

25-year, 24-hour storm event (Burgess 1991). The study concluded the internal and external drainage systems could safely carry run-on/run-off from this storm event with minor maintenance and upgrades made to the existing ditches and culverts. The ICDF landfill has been designed to accommodate the run-on/run-off from a 25-year, 24-hour storm event (DOE-ID 2001a; EDF-ER-270).

1.2.7.3 Man-made Surface Water Features. Man-made surface water features in the vicinity of the INTEC consist of two percolation ponds (that recently went off-line in August 2002) used for disposal of water in the service waste system (formerly injected into the aquifer via the Idaho Chemical Processing Plant [ICPP] injection well) and sewage treatment lagoons and infiltration trenches for treated water. In addition to these features, several landscaped areas at the INTEC historically have been watered during the summer months, and a network of ditches is used to channel run-off from the facilities after precipitation events. Some of the precipitation run-on/run-off is channeled to an old gravel pit in the northeastern portion of INTEC.

1.2.8 Water Quality and Usage

The natural water quality in the SRPA underlying the INEEL is generally characteristic of the recharge areas. For instance, in the western part of the INEEL the water quality consists of calcium, magnesium, bicarbonate, and carbonate as the chief ions that are derived from the limestone and dolomite recharge areas abundant to the north and west of INEEL. In the eastern portion, higher percentages of sodium and potassium are typical that are derived from the silicic volcanic rocks originating in mountains to north and northeast of INEEL.

The water quality in the SRPA at and downgradient from the INTEC has been adversely impacted due to past facility operations. The majority of INTEC-related SRPA contamination is due to the past disposal of wastes through the ICPP injection well. Contamination in the aquifer is also due to downward migration of contaminants from surface soils and perched groundwater zones. The injection well was the primary source for waste disposal from 1952 through February 1984 and was used intermittently for emergency situations until 1986. The average discharge to the well during this period was approximately 1.4 billion L/year (363 million gal/year) or about 3.8 million L/day (1 million gal/day). It has been estimated a total of 22,000 Ci of radioactive contaminants have been released in 4.2×10^{10} L (1.1×10^{10} gal) of water. The vast majority of this radioactivity is attributed to H-3 (approximately 96%) with minor components of I-129 and Sr-90.

Groundwater from the SRPA supplies most of the water for the area surrounding the INEEL and essentially all drinking water consumed within the ESRP. The water from the aquifer is used for agriculture, food processing, aquaculture, and domestic, rural, public, and livestock water supplies. In total, nearly 18 trillion L (4.7 trillion gallons) of water are drawn from the aquifer annually, with the majority going to agriculture.

The SRPA is the only source of water used at the INEEL. The combined groundwater withdrawal averages approximately 3×10^7 L/day (7×10^6 gal/day) or 8,000 acre-ft/year. The water withdrawn from the aquifer is used for potable water on the Site, for ground maintenance, and for necessary facility operations.

1.2.9 Soils

In general, INEEL soils have formed by alluvial or eolian deposition over basalt lava flows and are derived from silicic volcanic and Paleozoic rocks from nearby mountains and buttes. Rock outcrops are common and some soils are relatively shallow. Figure 1-11 depicts, in general, the soils typically found

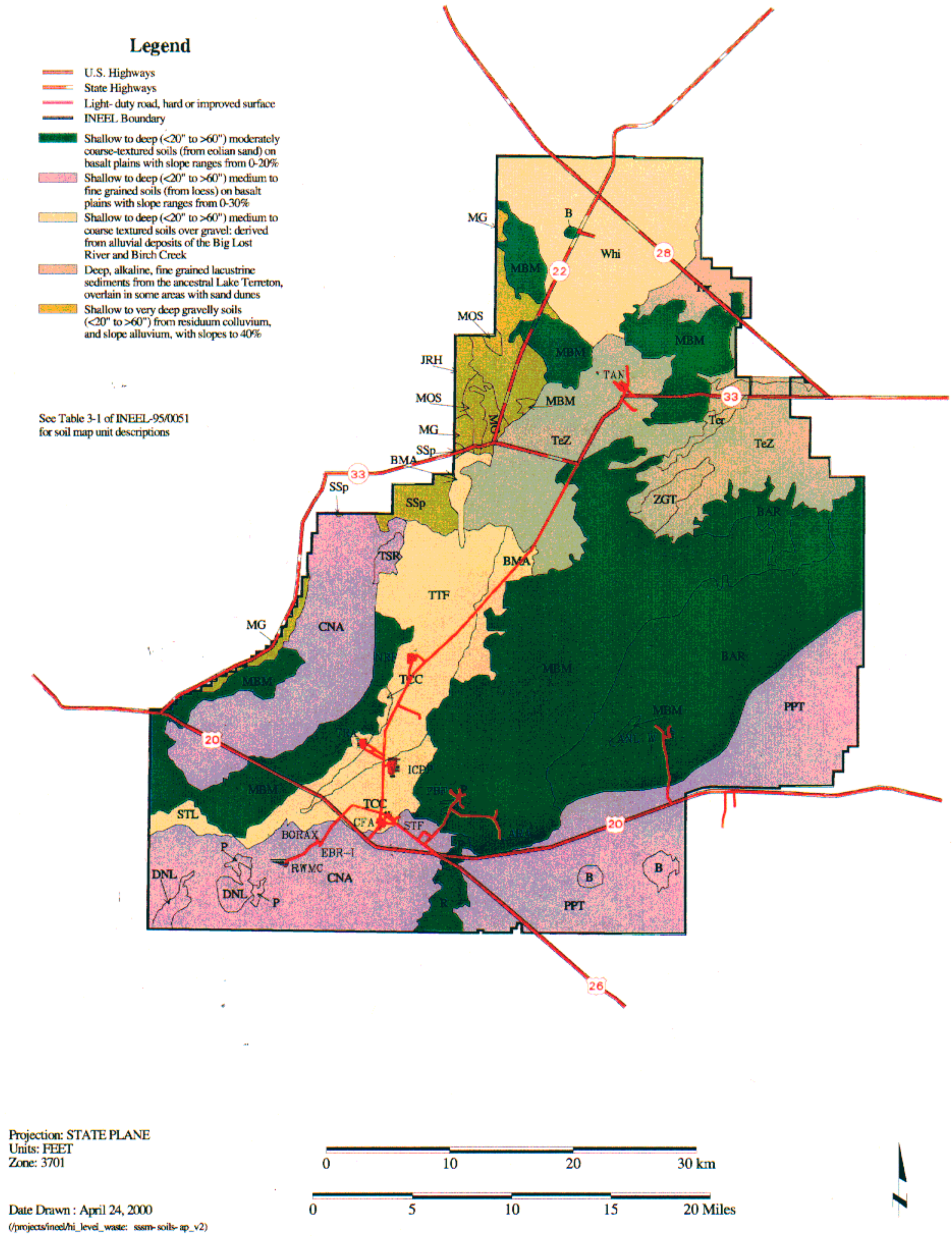

Figure 1-11. Soils typically found on the INEEL.

on the INEEL. The map constitutes an Order 4 or 5 soil survey as defined by the U.S. Natural Resources Conservation Service. Complete descriptions of the mapping units and detailed descriptions of the soil series that compose the mapping units are provided in Olson et al. (1995). Approximately 19 map units compose the general soil map. The deeper soils are located in the central and northern portions of the Site, while shallower, rocky soils are generally found in the southern portion.

Soils in the vicinity of the Big Lost River and Birch Creek tend to be medium-to-coarse textured over gravel and are derived from alluvial deposits of the Big Lost River and Birch Creek. These soils range from shallow, less than 51 cm (20 in.), to deep, more than 152 cm (60 in.). The cation-exchange capacity, an indicator of the ability of a soil to adsorb potential contaminants, ranges from 0 to 30 meq/100 g. Soils in the north-central portion of the Site tend to be deep alkaline, fine-grained latchstring sediments from the ancestral Lake Terreton, overlain in some areas with sand dunes. These soils have clay contents ranging from 2 to 48%. Soils in the central portion of the Site tend to be moderately coarse-textured (from eolian sand) on basalt plains at depths ranging from shallow, less than 51 cm (20 in.) to deep, more than 152 cm (60 in.) The soils tend to have clay contents ranging from 2 to 35% and cation-exchange capacities ranging from 1 to 30 meg/100 g. Soils in the southern portions of the Site tend to be medium- to fine-grained soils (from loess) on basalt plains and also are shallow to deep. Soils along the margins of the western Site boundary tend to be shallow to very deep gravelly soils from residual colluvium and slope alluvium. These soils have clay contents ranging from 2 to 37% and cation-exchange capacities ranging from 4 to 25 meg/100 g.

The INTEC soils are shallow to deep <51 cm (20 in.) to >152 cm (60 in.), medium-to-coarse textured soils over gravel derived from alluvial deposits of the Big Lost River. INTEC surficial sediment thickness ranges from 6.4 to 18 m (21 to 60 ft) with a mean of 11.5 m (38 ft). The soil type has been mapped as Typic Camborthids-Typic Calciorthids (Olson et al. 1995). These soils are capped with a desert pavement and have calcic horizons within the top 25.4 cm (10 in.) of soil. In the area south of INTEC, carbonate coatings have been noted on the bottoms of Typic Camborthids-Typic Calciorthids alluvial gravels, free lime is present in the soils, and the subsoils react with hydrogen chloride. Soils are generally loams or silt loams over gravelly loams and sandy loams (generally falling into the coarse loamy over sandy or loamy skeletal families).

1.2.10 Ecology

The following sections discuss the plant and animal species and communities that may be found on the Site including threatened, endangered, and sensitive species.

1.2.10.1 Flora. The INEEL represents the largest remnant of undeveloped, ungrazed sagebrush steppe ecosystem in the Intermountain West (DOE-ID 1996). This ecosystem has been listed as critically endangered with less than 2% of its original coverage remaining (Noss et al. 1995; Saab and Rich 1997).

In 1975, the INEEL Site was dedicated as one of five DOE National Environmental Research Parks. It is an outdoor laboratory used to study ecological relationships and the effects of human activities on natural systems. In addition, it provides a unique setting for scientific investigation because the public has been excluded from much of the area for the past 25 years. Ecological data collected from the Idaho National Environmental Research Park provide a basis for analyzing environmental changes over time and assessing the effect of human influence on the environment.

Research on the flora and fauna of the INEEL Site has largely been conducted by or in conjunction with the DOE Radiological and Environmental Sciences Laboratory (RESL). The physical aspects of the INEEL Site and its flora and fauna are typical of cold, high-altitude, sagebrush ecosystems found in the western United States.

Much of the following discussion of the flora and fauna at the INEEL is from the *Environmental Resource Document for the Idaho National Engineering Laboratory* (Irving 1993). This report contains additional detailed information and references to specific ecological studies.

Extensive surveys of INEEL vegetation were carried out in 1952, 1958, and 1967 using 150 permanent transects established and maintained for this purpose (Harniss and West 1973). McBride et al. (1978) and Jeppson and Holte (1978) also have described vegetation.

More recently, Anderson et al. (1996b) broadly described 10 vegetation classes and plant communities that occur on the INEEL (Figure 1-12). These communities do not represent homogeneous community types but integrated communities that share dominant species and are more similar to each other than to communities represented by other vegetation classes. Sagebrush steppe is the dominant community on the INEEL. Other community types include juniper woodlands, grasslands, low shrubs on lava, sagebrush-rabbitbrush, sagebrush-winterfat, salt desert shrub, wetlands, playas, bare ground or disturbed areas, and lava. Figure 1-12 depicts the distribution of vegetation at the INEEL.

Several studies have been conducted at the INEEL on the plant rooting depths, especially for the RWMC Subsurface Disposal Area (SDA). Studies of plant uptake of radionuclides at the INEEL have focused primarily on (a) determining if deep-rooted plants are a mechanism for waste pit intrusion and subsequent uptake of radionuclides and (b) analyzing inventories of radionuclides in aerial portions of plants. Aerial portions of plants are important because they can potentially transport subsurface contaminants through dispersal of leaves, consumption by herbivores, use by birds as nesting materials, and wildfire.

One RWMC SDA study comparing radionuclide uptake by crested wheatgrass (rooting depth 1 to 1.5 m [3 to 4.9 ft]) with that by Russian thistle (rooting depth 1 to 5 m [3 to 16 ft]) showed higher radionuclide concentrations in the deeper-rooted species (Arthur 1982). Examples of other deep-rooting species are rabbitbrush and sagebrush. General examples of shallow-rooting plant types are grasses and annual forbs.

Reynolds and Fraley (1989) found that the roots of big sagebrush extended to a depth of 225 cm (89 in.), green rabbitbrush to a depth of 190 cm (75 in.), and Great Basin wild rye had roots up to 200 cm (79 in.) deep at the SDA. Maximum lateral spread of the roots of both big sagebrush and Great Basin wild rye was 90 cm (35.5 in.) and occurred at a depth of 40 cm (15.8 in.). In addition, studies indicate root penetration of up to 1.6 m (5.2 ft) for sodar and crested wheatgrass at the INEEL (Markham 1987).

1.2.10.2 Fauna. The INEEL supports a variety of wildlife including small mammals, birds, reptiles, and a few large mammals.

Aquatic life on the INEEL is limited and depends mainly upon the flow of the Big Lost River. During several months of the year, and even during some entire years, the river does not flow. However, during spring run-off and periods of high rainfall, the diversion system (at the southern boundary of the INEEL) and the Big Lost River sinks (at the northern boundary of the INEEL) support water flow during periods of water accumulation. This normally occurs less than 2 or 3 months in the spring. Fish species observed in the Big Lost River on the INEEL include rainbow trout, mountain whitefish, eastern brook trout, Dolly Varden char, Kokanee salmon, and the shorthead sculpin (Overton et al. 1976).

A total of 219 vertebrate species have been recorded on the INEEL. Vertebrate species include six species of fish, one amphibian, nine reptiles, 164 birds, and 39 mammals (Reynolds et al. 1986). Several vertebrate species present on the INEEL are considered sagebrush-obligate species, meaning that they rely upon sagebrush for survival. Among others, these species include sage sparrow *(Amphispiza belli*),

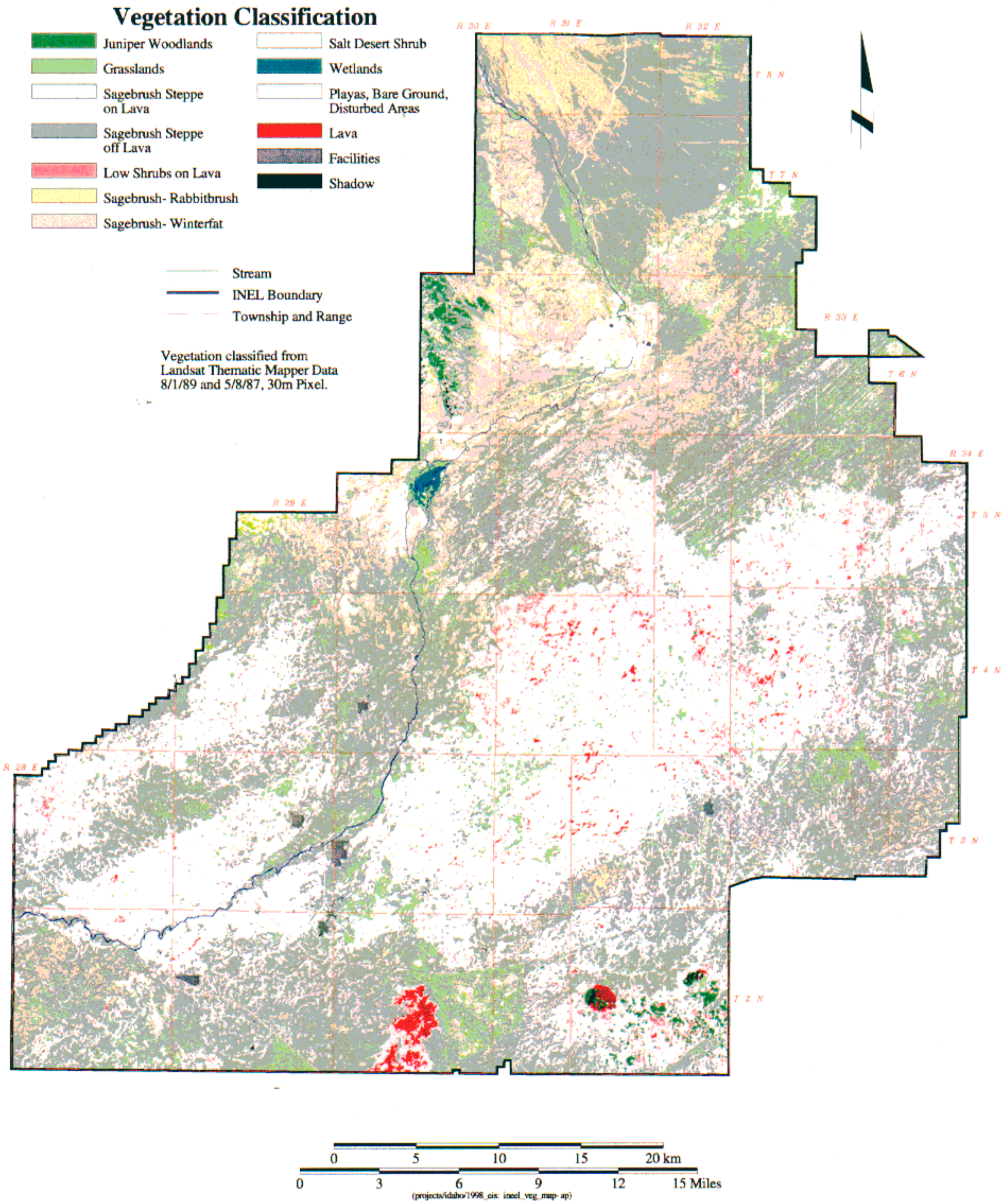

Figure 1-12. Approximate distribution of vegetation at the INEEL.

Brewer's sparrow *(Spizella breweri*), northern sagebrush lizard *(Sceloporus graciosus*), sage grouse *(Centrocercus urophasianus*), and pygmy rabbit *(Brachylagus idahoensis*).

A total of 740 insect species have been recorded at the INEEL; 226 of these species have not yet been identified beyond the family level. The majority of the abundant species belong to the orders Hymenoptera (wasps and ants) and Diptera (flies).

Studies have been performed on burrowing characteristics of small mammals such as ground squirrels, deer mice, and voles (Arthur et al. 1983; Markham 1987; Reynolds and Laundre 1988). Results of the studies indicate burrows no deeper than 140 cm (55 in.) at the INEEL.

1.2.10.3 Threatened, Endangered, and Sensitive Species. A list of threatened or endangered (T/E) and sensitive species that may occur on the INEEL is given in Table 1-2. The list was originally compiled from the U.S. Fish and Wildlife Service (USFWS) (USFWS 1996, 1997); the Idaho Department of Fish and Game (IDFG) Conservation Data Center (CDC) threatened, endangered, and sensitive species for the State of Idaho (CDC 1994); and RESL documentation for the INEEL (Reynolds 1994; Reynolds et al. 1986). This list (USFWS 2001) was most recently updated in February 2002.[a]

The only species documented at the INEEL and currently recognized as threatened or endangered under the Endangered Species Act is the bald eagle, which was recently down-listed to threatened. The peregrine falcon, recently removed from the federal list, remains on the endangered list for the State of Idaho.

Table 1-2. Threatened or endangered species, sensitive species, and species of concern that may be found on the INEEL.

Common Name[a]	Scientific Name	Federal Status[b,c]	State Status[c]	BLM Status[c]	USFS[d] Status[c]
Plants					
Lemhi milkvetch	*Astragalus aquilonius*	—	S	S	S
Painted milkvetch[e]	*Astragalus ceramicus var. apus*	SC	R	—	—
Plains milkvetch	*Astragalus gilviflorus*	—	1	S	S
Winged-seed evening primrose	*Camissonia pterosperma*	—	S	S	—
Nipple cactus[e]	*Coryphantha missouriensis*	—	R	—	—
Spreading gilia	*Ipomopsis (=Gilia) polycladon*	—	2	S	—
King's bladderpod	*Lesquerella kingii var. cobrensis*	—	M	—	—
Tree-like oxytheca[e]	*Oxytheca dendroidea*	—	R	R	—
Inconspicuous phacelia[f]	*Phacelia inconspicua*	C	SSC	S	S
Ute ladies' tresses[f]	*Spiranthes diluvialis*	LT	—	—	—
Puzzling halimolobos	*Halimolobos perplexa var. perplexa*	—	M	—	S
Slender moonwort[f]	*Botrychium lineare*	R	GP1	—	—
Birds					
Peregrine falcon	*Falco peregrinus*	R	E	—	—
Merlin	*Falco columbarius*	—	P	S	—
Gyrfalcon	*Falco rusticolus*	—	SSC	S	—
Bald eagle	*Haliaeetus leucocephalus*	LT	T	—	—
Ferruginous hawk	*Buteo regalis*	W	SSC	S	—
Black tern	*Chlidonias niger*	—	SSC	—	—
Northern pygmy owl[f]	*Glaucidium gnoma*	W	SSC	—	—

a. Updated by N. L. Hampton, BBWI, February 4, 2002.

Table 1-2. (continued).

Common Name[a]	Scientific Name	Federal Status[b,c]	State Status[c]	BLM Status[c]	USFS[d] Status[c]
Burrowing owl	*Athene(=Speotyto) cunicularia*	SC	—	S	—
Common loon	*Gavia immer*	W	SSC	—	—
American white pelican	*Pelicanus erythrorhynchos*	—	SSC	—	—
Great egret	*Casmerodius albus*	—	SSC	—	—
White-faced ibis	*Plegadis chihi*	SC	—	—	—
Long-billed curlew	*Numenius americanus*	SC	—	S	—
Loggerhead shrike	*Lanius ludovicianus*	SC	NL	S	—
Northern goshawk	*Accipiter gentilis*	W	P	—	S
Swainson's hawk	*Buteo swainsoni*	—	—	S	—
Trumpeter swan	*Cygnus buccinator*	SC	SSC	S	S
Sharptailed grouse	*Tympanuchus phasianellus*	SC	—	S	S
Boreal owl	*Aegolius funereus*	W	SSC	S	S
Flammulated owl	*Otus flammeolus*	W	SSC	—	S
Yellow-billed cuckoo[f]	*Coccyzus americanus*	C	—	—	—
Greater sage grouse	*Centrocercus urophasianus*	SC	—	—	—
<u>Mammals</u>					
Gray wolf[g]	*Canis lupus*	LE/XN	E	—	—
Pygmy rabbit	*Brachylagus (=Sylvilagus) idahoensis*	W	GSC	S	—
Townsend's Western big-eared bat	*Corynorhinus (=Plecotus) townsendii*	SC	SSC	S	S
Merriam's shrew	*Sorex merriami*	—	U	—	—
Long-eared myotis	*Myotis evotis*	W	U	—	—
Small-footed myotis	*Myotis ciliolabrum (=subulatus)*	W	U	—	—
Western pipistrelle[f]	*Pipistrellus hesperus*	W	SSC	—	—
Fringed myotis[f]	*Myotis thysanodes*	W	SSC	—	—
California myotis[f]	*Myotis californicus*	W	U	—	—
<u>Reptiles and amphibians</u>					
Northern sagebrush lizard[h]	*Sceloporus graciosus*	SC	—	—	—
Ringneck snake[f]	*Diadophis punctatus*	C	SSC	S	—
Night snake[e]	*Hypsiglena torquata*	—	—	R	—
<u>Insects</u>					
Idaho pointheaded grasshopper[f]	*Acrolophitus punchellus*	W	—	—	—
<u>Fish</u>					
Shorthead sculpin[f]	*Cottus confusus*	—	SSC	—	—

a. This list was compiled by N. Hampton from letters from the U.S. Fish and Wildlife Service (USFWS) (1996, 1997, 2001) for threatened or endangered, and sensitive species listed by the Idaho Department of Fish and Game (IDFG) Conservation Data Center (CDC 1994 and IDFG Web site) and Radiological Environmental Sciences Laboratory documentation for the INEEL (Reynolds et al. 1986).

b. The USFWS no longer maintains a candidate (C2) species listing but addresses former listed species as "species of concern" (USFWS 1996). The C designation replaces C2.

c. Status codes: INPS=Idaho Native Plant Society; S=sensitive; 2=State Priority 2 (INPS); M=State of Idaho monitor species (INPS); U= undetermined, 1=State Priority 1 (INPS); LE=listed endangered; P=protected nongame species, E=endangered; T = threatened; XN = experimental population, nonessential; SC=species of concern, SSC=species of special concern; W = watch species and C = candidate for listing , see footnote b, formerly Category 2 (defined in CDC 1994). BLM=Bureau of Land Management; R = removed from sensitive list (nonagency code added here for clarification).

d. U.S. Forest Service (USFS) Region 4.

e. Recent updates that resulted from Idaho State Sensitive Species meetings (BLM, USFWS, INPS, and USFS) (IDFG Website).

f. No documented sightings at the INEEL; however, the ranges of these species overlap the INEEL and are included as possibilities to be considered for field surveys.

g. Anecdotal evidence indicates that isolated wolves may occur on the INEEL. However, no information exists to substantiate hunting or breeding on-Site (Morris 2001).

h. The sagebrush lizard was placed on the list as a result of a miscommunication; however, it remains on the official USFWS update periodically issued for the INEEL (N. Hampton BBWI, lecture at IDFG by Dr. Charles Peterson, Idaho State University, January 10, 2002, Idaho Falls, ID).

A number of former C2 species recorded at the INEEL no longer have status under the Endangered Species act but remain species of concern. These include the burrowing owl (*Athene cunicularia*), white-faced ibis (*Plegadis chichi*), trumpeter swan (*Cygnus buccinator*), long-billed curlew (*Numenius americanus*), loggerhead shrike (*Lanius excubitor*), greater sage grouse (*Centrocercus urophasianus*), sharp-tailed grouse (*Tympanuchus phasianellus*), and Townsend's big-eared bat (*Corynorhinus townsendii).* Painted milk-vetch (*Astragalus ceramicus* var. *apus*) also remains on the USFWS periodic update for the INEEL (USFWS 2001), but has been removed from the State of Idaho list. The sagebrush lizard (*Sceloporous graciosus*) was designated as a candidate for listing through a miscommunication[b] but remains as a species of concern on the periodic T/E update for the INEEL (USFWS 2001).

Five additional species documented at the INEEL also appear on the federal watch list and the USFWS list of species of concern for the INEEL (USFWS 2001), including the ferruginous hawk (*Buteo regalis*), pygmy rabbit (*Brachylagus idahoensis*), Merriam's shrew (*Sorex merriami*), long-eared myotis (*Myotis evotis*), and small-footed myotis (*Myotis ciliolabrum*).

1.3 Related Documents

The following discussion describes the regulatory framework in which this CA was prepared. The EPA proposed listing the INEEL on the National Priorities List (NPL) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) July 14, 1989 (54 FR 19820). After considering the 60-day public comment period following the proposed INEEL listing, EPA issued a final ruling that listed the INEEL as an NPL site in the FR, November 21, 1989 (54 FR 48184).

The Federal Facility Agreement and Consent Order (FFA/CO) between the EPA Region X, the State of Idaho Department of Health and Welfare (IDHW), and the DOE-ID was developed to establish the procedural framework and schedule for developing, prioritizing, implementing, and monitoring response actions at the INEEL in accordance with CERCLA, RCRA, and the Idaho Hazardous Waste Management Act (DOE-ID 1991). The FFA/CO identified 10 waste area groups (WAGs) to be addressed through the CERCLA process, with INTEC designated as WAG 3. A Comprehensive Remedial Investigation/Feasibility Study (RI/FS) (DOE-ID 1997) identified release sites at INTEC that pose a threat to human health and/or the environment requiring remedial action to mitigate these risks. In accordance with the signed OU 3-13 Final Record of Decision (ROD) (DOE-ID 1999), the ICDF Complex was identified as a selected remedy for the OU 3-13 Group 3, Other Surface Soils. As part of the selected remedy for Group 3, the ICDF Complex was constructed at INTEC to allow on-Site disposal of WAG 3 and other CERCLA-generated wastes at the INEEL. The ICDF was designed and constructed to meet Idaho Administrative Procedures Act (IDAPA) 58.01.05.008 (40 CFR 264.301) for hazardous waste, 40 CFR 761.75 for PCB, and DOE Order 435.1 for radioactive waste landfill design and operating substantive requirements. The ICDF landfill will operate, close, and postclose in accordance with the substantive requirements of IDAPA 58.01.05.008 (40 CFR 264 Subparts F, G, and N) and maintain Site access restrictions and institutional controls throughout the postclosure period. Permanent land-use restrictions will be placed on the ICDF Complex, which will be closed in place, for as long as land use and access restrictions are required to be protective of human health and the environment. Maintenance will be performed on the final cover for the closed ICDF landfill as necessary to prevent the release of leachate to underlying groundwater that would result in exceedance of groundwater quality standards (i.e., maximum contaminant levels [MCLs]) in the SRPA. The final landfill cover has been designed to protect against inadvertent intrusion for a period of at least a 1,000 years. Remedial actions taken under the ROD (DOE-ID 1999) will be reviewed under the CERCLA 5-year review process to ensure their

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b. N. L. Hampton, BBWI, lecture at IDFG by Dr. Charles Peterson, Idaho State University, January 10, 2002, Idaho Falls, ID.

protectiveness. Five-year reviews will also ensure that any changes in the physical configuration of the ICDF landfill where there is suspicion of a release of hazardous or radioactive substances will be managed to achieve remediation goals established in the ROD (DOE-ID 1999). The 5-year reviews will continue as long as contaminants exist at levels that result in restricted or limited site usage.

Waste disposal constraints for the ICDF landfill are outlined in *Waste Acceptance Criteria for ICDF Landfill* (DOE-ID 2002b). The *ICDF Operations and Maintenance Plan* (DOE-ID 2003b) contains the standard operating procedures and associated job safety analyses for all operations and maintenance activities to be conducted at the ICDF Complex. The *ICDF Complex Waste Verification Sampling and Analysis Plan* (DOE-ID 2003c) establishes the requirements for verification of untreated waste destined for disposal at the ICDF landfill and identifies the process to confirm that key parameters (those that limit waste acceptance in the landfill) in the waste do not exceed the limits on the Material Profile.

In accordance with DOE O 5400.1 (canceled in 1995 by DOE O 231.1), a groundwater protection management plan has been instituted for the site and is described in the following reports: *INEL Groundwater Protection Management Plan* (DOE-ID 1993a), *Idaho National Engineering Laboratory Groundwater Monitoring Plan* (DOE-ID 1994a), and *Idaho National Engineering Laboratory Groundwater Monitoring Plan Update* (DOE-ID 2002c). Groundwater protection requirements applicable to operation, closure, and long-term performance of the landfill include prevention of the release of leachate to underlying groundwater that would result in exceeding applicable State of Idaho groundwater quality standards (i.e., MCLs) in the SRPA (DOE-ID 1999).

INEEL activities must comply with two stormwater pollution prevention plans: one for industrial activities (DOE-ID 1998a), the other for construction activities (DOE-ID 1993b). The plans address stormwater discharges associated with industrial activities to waters of the United States. EPA's goal in requiring these plans is to improve water quality by reducing pollutants in stormwater discharges. Another report that supports this CA is the *Idaho Chemical Processing Plant Safety Document* (PSD-4.2).

The Remedial Design/Construction Work Plan (DOE-ID 2002a) provides the framework for design and construction, and the Remedial Action Work Plan (DOE-ID 2003d) describes the operation of the ICDF Complex. Primary document sources for the ICDF landfill design criteria are

- DOE-ID, 1999, *Final Record of Decision, Idaho Nuclear Technology and Engineering Center, Operable Unit 3-13,* DOE/ID-10660, Rev. 0, Department of Energy Idaho Operations Office; U.S. Environmental Protection Agency, Region 10; and State of Idaho Department of Health and Welfare, October 1999.

- DOE-ID, 2000, *Remedial Design/Remedial Action Scope of Work for Waste Area Group 3, Operable Unit 3-13*, DOE/ID-10721, Rev. 1, U.S. Department of Energy Idaho Operations Office, February 2000.

- DOE-ID, 2002, *INEEL CERCLA Disposal Facility Remedial Design/Construction Work Plan,* DOE/ID-10848, Rev. 1, U.S. Department of Energy Idaho Operations Office, May 2002.

- DOE-ID 2003, *INEEL CERCLA Disposal Facility Complex Remedial Action Work Plan*, DOE/ID-10984, Rev. 0, U.S. Department of Energy Idaho Operations Office, February 2003.

- TFR-71, 2002, "Technical and Functional Requirements-WAG 3 INEEL CERCLA Disposal Facility and Evaporation Pond," Rev. 2, Idaho National Engineering and Environmental Laboratory, May 2002.

- TFR-2520, 2002, "Technical and Functional Requirements for the ICDF Complex Control System," Rev. 0, Idaho National Engineering and Environmental Laboratory, May 2002.

- DOE-ID, 2000, *Conceptual Design Report for the INEEL CERCLA Disposal Facility and Evaporation Pond*, DOE/ID-10806, Rev. 0, U.S. Department of Energy Idaho Operations Office, November 2000.

- 40 CFR 264.301, 1992 "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart N, "Landfills," Section 301, "Design and Operating Requirements," *Code of Federal Regulations*, Office of the Federal Register, January 1, 1992.

- 40 CFR 761.75, 1999, "Polychlorinated Biphenyls (PCBs) Processing, Distribution in Commerce and Use Prohibitions," Section 75, "Chemical Waste Landfills," *Code of Federal Regulations*, Office of the Federal Register, July 1, 1999.

Documents used in the development of this CA include

- DOE O 435.1, "Radioactive Waste Management," U.S. Department of Energy, August 28, 2001.

- DOE G 435.1-2 Part C, "Composite Analysis Standard Format and Content," January 2001.

- DOE-ID, 2003, *Performance Assessment for the INEEL CERCLA Disposal Facility*, DOE/ID-10978, Rev. 0, U.S. Department of Energy Idaho Operations Office, August 2003.

- DOE-ID, 2001, *Performance Assessment for the Tank Farm Facility at the Idaho National Engineering and Environmental Laboratory*, DOE/ID-10966, Rev.0, U.S. Department of Energy Idaho Operations Office, December 2001.

- DOE-ID, 2002, *Composite Analysis for the Tank Farm Closure,* DOE/ID-10974, U.S. Department of Energy Idaho Operations Office, March 2002.

- Maheras, S. J., A. S. Rood, S. O. Magnuson, M. E. Sussman, and R. N. Bhatt, 1994, *Radioactive Waste Management Complex Low-Level Waste Radiological Performance Assessment, INEEL*, EGG-WM-8773.

- Maheras, S. J., A. S. Rood, S. O. Magnuson, M. E. Sussman, and R. N. Bhatt, 1997, *Addendum to Radioactive Waste Management Complex Low-Level Waste Radiological Performance Assessment* (EGG-WM-8773), INEL/EXT-97-00462.

- Case, M. J., A. S. Rood, J. M. McCarthy, S. O. Magnuson, B. H. Becker, T. K. Honeycutt, 2000, *Technical Revision of the Radioactive Waste Management Complex Low-Level Waste Radiological Performance Assessment for Calendar Year 2000*, INEEL/EXT-2000-01089, Idaho National Engineering and Environmental Laboratory, Idaho Falls Idaho.

1.4 Performance Criteria

The CA is a conservative assessment of the cumulative impacts from planned ICDF landfill LLW disposal activities and all other sources of radioactive contamination that could interact with the ICDF landfill to affect the radiological dose to future members of the public. The projected total dose to a hypothetical future member of the public from these sources is compared with the DOE primary dose limit of 100 mrem/yr and with the 30 mrem/yr dose constraint. If the calculated dose exceeds the 100 mrem/yr primary dose limit, alternatives must be identified for reducing future doses to tolerable levels. If the calculated dose exceeds the 30 mrem/yr dose constraint, an options analysis will be prepared to consider the actions that could be taken to reduce the calculated dose and to consider the costs of those actions. The CA process, including an options analysis and recommendations for further action, will support the DOE decision-making process to ensure that LLW disposal will not compromise future radiological protection of the public.

The ICDF landfill is expected to accept wastes starting in 2003 and continue disposal operations for 15 years through 2018. Active institutional controls will be in place for 100 years following landfill closure in 2018. The closure strategy for the landfill assumes an engineered cover and institutional and land-use controls. The *INEEL Comprehensive Facility & Land Use Plan* (DOE-ID 1996) and the INTEC Final Record of Decision (DOE-ID 1999) describe the land use for the INEEL and INTEC. Land use at the INEEL is currently government-controlled industrial use. Presently, access to the INEEL facilities requires proper clearance, training, or escort and controls to limit the potential for unacceptable exposures. These controls are estimated to be in place for the next 100 years (DOE-ID 1996, 1999).

The time of compliance for the CA is 1,000 years following disposal facility closure. Calculations will also be carried out to determine the maximum dose and the time of the maximum dose. The point of assessment for the CA is 100 m downgradient of the INEEL boundary for the first 100 years and then 100 m downgradient of the ICDF Complex for the remaining 1,000-year compliance period.

1.5 Summary of Key Assessment Assumptions

Key assumptions used in the CA that are most critical to the analysis of performance are highlighted below.

1.5.1 Source Inventory and Release Rates

The following summarizes the critical assumptions related to the source inventory and the release rates for the ICDF landfill.

- The entire waste is assumed to be compacted soil. This is a conservative assumption with respect to the leaching of contaminants from the facility. There is relatively little uncertainty in this assumption because the waste will be predominantly soils that will be compacted during emplacement in the facility. All containerized and grouted wastes should be more stable than the compacted soil with respect to leaching of contaminants from the facility. Therefore, treating the waste as 100% compacted soil is a conservative assumption.

- Because the maximum or the 95% upper confidence limit (UCL) concentrations have been used to estimate soil concentrations, the entire volume of soil is assumed to be contaminated by a concentration equal to the maximum or 95% UCL. This is a conservative estimate of the contaminant inventory. Actual inventory is expected to be significantly lower.

- The engineered disposal system will completely isolate all radionuclides from the subsurface up to the time of closure of the facility in the year 2018. Failure of the engineered system has not been evaluated; however, the leachate collection system is a simple design and it is reasonable to expect that it will operate as designed.

- Radionuclides that leach from the waste soil travel vertically and mix instantaneously in the engineered clay layer below the waste. First-order processes describe releases from the waste and clay layer. This assumption is reasonable based on the design of the facility. The clay layer will provide significant sorption of most of the radionuclides, thereby providing protection to the groundwater quality.

- The inventory and, when possible, the flux of contaminants from the source to the vadose zone or to the aquifer for each source and contaminant were taken from previous investigations.

- Grouted sources are stabilized for 500 years. During this time, there is no infiltration through the grout and, therefore, no leaching of contaminants to the vadose zone. It is assumed that, after 500 years, the grout in the tanks and facilities would have the same hydrogeologic transport characteristics as the surrounding soil. However, chemical properties of the grout and concrete would remain unchanged.

1.5.2 Subsurface Models

The following summarizes the critical assumptions related to the subsurface models used for the ICDF landfill analysis.

- The ICDF landfill cover has been designed to last for 1,000 years. However, this composite analysis assumes the cover will perform as designed for 500 years (one-half the design life) until the year 2518 and then fail over a 500-year period from 2518 until 3018. During the period from year 2518 until 3018, the cover gradually deteriorates and the infiltration through the cover linearly increases from 0.01 cm/yr in year 2518 until it returns to its background rate (1 cm/yr) in year 3018.

- The landfill cover only restricts water flow through the waste. While the cover is in place, most moisture is retained in the soil and released through evapotranspiration or runs off the cap into the surrounding soil where it infiltrates. A small amount passes through the cover and into the waste. The enhanced infiltration around the cover results in vadose zone water travel times that are equivalent to background vadose zone water travel times during operations and the periods of institutional control and postinstitutional control. Therefore, the cover is assumed to significantly reduce the rate of contaminant release from the ICDF but not the time to the first arrival of contaminants to the aquifer. This assumption is explained in detail in Section 3.2.1 and Figures 3-2 and 3-3.

- Water travel times through the vadose zone fractured basalt are instantaneous; therefore, the vadose zone travel times are controlled by the thickness of the sedimentary interbeds.

- The aquifer is composed of an equivalent homogeneous porous medium of infinite lateral extent and finite thickness. The predicted ICDF performance is much more sensitive to the source release than to the mixing in the aquifer; therefore, this assumption is not expected to significantly influence the predicted performance of the ICDF.

1.6 Data Quality Objectives

Data quality objectives (DQOs) match the type, quality, and quantity of data collected to the needs of the decision-maker to provide confidence in decisions that will be based on the data. DQOs for the CA are established by identifying the types of decisions that will be made and identifying the data uses and needs. The primary decision types addressed by the CA are planning decisions. The CA is intended to be a conservative estimate of the cumulative impacts of the ICDF landfill and other sources at the INEEL that may interact to contribute to the total dose to a hypothetical future member of the public. The intent of the CA is to provide DOE with ample information to make reasonable management decisions regarding the ICDF landfill and resource expenditure. Data used in the CA must be of sufficient quality to support justification of assumptions and, therefore, ensure credibility. The general processes used to ensure data quality in the ICDF landfill inventory data and computer simulations used in the CA are described below.

1.6.1 Inventory Data

"INEEL CERCLA Disposal Facility Design Inventory," EDF-ER-264, was prepared based upon the *CERCLA Waste Inventory Database Report* (DOE-ID 2000b). This database report describes the data sources, database architecture, quality assurance methods and results, and data uses and limitations. The Engineering Design File (EDF) provides a conservative estimate of the waste inventory that is expected to be disposed in the landfill during the first 10 years of operation. This EDF was used to assist in the design basis of the ICDF landfill.

1.6.2 Computer Simulation Codes

Company policies and procedures establish the company-wide uniform standard for the management and maintenance of software. Software quality assurance requirements including verification and validation requirements for software used by INEEL personnel are found in (a) DOE orders, (b) ASME (1997) (NQA-1), (c) company policies and procedures, and (d) other codes and standards, such as those developed by American National Standards Institute and Institute of Electrical and Electronic Engineers.

GWSCREEN is a groundwater assessment code that was developed for the assessment of the groundwater pathway from leaching of radioactive and nonradioactive substances from surface or buried sources. The code was designed for implementation in the Track I and Track II assessment of CERCLA sites identified as low probability hazard at the INEEL (DOE-ID 1992 and DOE-ID 1994b). In addition, the code has been successfully applied to numerous other sites and problems.

The code calculates the limiting soil concentration and inventory so that, after leaching and transport of the contaminant to the aquifer, regulatory contaminant levels in groundwater are not exceeded. Groundwater concentrations and dose results are also output at user-specified times. The code uses a mass conservation approach to model three processes: (1) contaminant release for a source volume, (2) contaminant transport in the unsaturated zone, and (3) contaminant transport in the aquifer. The source model considers the sorptive properties and solubility of the contaminant. Transport in the unsaturated zone is described by a plug flow model. Transport in the aquifer is calculated with a semianalytical solution to the advection dispersion equation in groundwater.

The GWSCREEN code, Version 2.5, includes transport, decay, and ingrowth of radioactive progeny. The simplifying, but conservative, assumption was made that progeny travel at the same rate as their parent.

GWSCREEN meets the requirements of Quality Level B documentation. Quality Level B documentation includes a software configuration management plan (Mathews 1992), verification and validation test plan (Rood 1993), and verification and validation report (Smith and Whitaker 1993).

RESRAD is a computer code developed at Argonne National Laboratory for the DOE to calculate site-specific RESidual RADioactive material guidelines as well as radiation dose and excess lifetime cancer risk to a chronically exposed onsite resident (Gilbert et al. 1989). This code system is designed to calculate site-specific residual radioactive material guidelines and radiation dose and excess cancer risk to an onsite resident (maximally exposed individual). Nine environmental pathways are considered: direct exposure, inhalation of dust and radon, and ingestion of plant foods, meat, milk, aquatic foods, soil, and water.

RESRAD uses a pathway analysis method in which the relation between radionuclide concentrations in soil and the dose to a member of a critical population group is expressed as a pathway sum, which is the sum of products of "pathway factors." Pathway factors correspond to pathway segments connecting compartments in the environment between which radionuclides can be transported or radiation transmitted. Radiation doses, health risks, soil guidelines, and media concentrations are calculated over user-specified time intervals. The source is adjusted over time to account for radioactive decay and ingrowth, leaching, erosion, and mixing. RESRAD uses a one-dimensional groundwater model that accounts for differential transport of parent and daughter radionuclides with different distribution coefficients.

RESRAD was selected for use in the CA because

- RESRAD is the only code designated by DOE in Order 5400.5 for the evaluation of radioactively contaminated sites.

- The EPA Science Advisory Board reviewed the RESRAD model and used RESRAD in their rulemaking on radiation site cleanup regulations.

- NRC has approved the use of RESRAD for dose evaluation by licensees involved in decommissioning.

- RESRAD has been applied to over 300 sites in the U.S. and other countries.

- The RESRAD code has been verified and has undergone several benchmarking analyses and has been included in the IAEA's VAMP and BIOMOVS II projects to compare environmental transport models.

2. SOURCE TERM DEVELOPMENT

This CA assesses and then quantifies the total potential dose to a hypothetical future member of the public from the ICDF landfill and all other radioactive material sources that will potentially contribute to the dose from the ICDF landfill, when operations at the INEEL have ceased. Since the CA is performed with respect to the ICDF landfill, doses from radioactive sources will only be calculated where and when they can contribute to the ICDF landfill dose. As discussed in detail in the ICDF Landfill Performance Assessment (PA) (DOE-ID 2003a), the ICDF landfill design cover is assumed to reduce infiltration through the waste to 0.01 cm/yr (0.004 in./yr) for the first 1,000 years. Consequently, the predicted dose from ICDF landfill contaminants is extremely small (essentially zero) for the first 1,000 years. Therefore, the doses in the aquifer from other sources during the first 1,000 years are not contributors to the ICDF landfill dose.

The CA accounts for all the wastes disposed of in the past as well as the waste forecast to be disposed. Radioactive material in the ground (or groundwater) as a result of DOE operations, such as liquid waste disposal to ponds, the aquifer, etc., are considered as potential sources. Radioactive material in the ground from spills or leaks from DOE operations or residues from remediation of such sources are also considered as potential sources.

The purpose of this section is to determine which sources of radioactive material should be considered for inclusion in the CA and to define their inventory and release functions. All sources in the vicinity of the ICDF landfill as well as sources upgradient and downgradient of the ICDF landfill are evaluated. Existing information (i.e., process knowledge, site history, etc.) are relied upon to identify the potential sources. Monitoring, field sampling, or other investigations were not performed for this CA.

The sources of radioactive material at the INEEL that may contribute to the potential dose from the active LLW disposal facility at the ICDF landfill are selected in accordance with the guidance document *Guidance for a Composite Analysis of the Impact of Interacting Source Terms on the Radiological Protection of the Public from Department of Energy Low-Level Waste Disposal Facilities* (DOE 1996). The following sections discuss the source term screening, radionuclide inventory, release rate for the source term, current radionuclide contaminant plumes in the aquifer, and effects of upgradient aquifer plumes on the ICDF landfill.

One class of potential sources that was ignored is the many operating facilities at the site for which there is insufficient information available to forecast the future residual contamination of the releases to the environment. An example of these operating facilities is the Fluorinel Dissolution Process and Fuel Storage. Ignoring the contribution of these operating facilities is equivalent to assuming that they will not leave behind a source of radionuclide contamination when decommissioned. As plans are developed, these facilities will have to be evaluated for their potential to contribute to the ICDF landfill CA dose.

The following sources were used to assemble information to determine which sources of radioactive material should be considered for inclusion in the CA:

- Appendix F from DOE-ID (1997), Comprehensive RI/FS for the Idaho Chemical Processing Plant OU-3-13 at the INEEL – Part A, RI/BRA Report (Final), DOE/ID-10534.

- DOE-ID, 1999, Final Record of Decision Idaho Nuclear Technology and Engineering Center, DOE/ID-10660, Rev. 0, October 1999.

- DOE-ID, 2000, CERCLA Waste Inventory Database Report for the Operable Unit 3-13 Waste Disposal Complex, DOE/ID-10803, December 2000.

- DOE-ID, 2001, Performance Assessment for the Tank Farm Facility at the Idaho National Engineering and Environmental Laboratory, DOE/ID-10966, Rev. 0, December 2001.

- Doornbos, M., 2001, INEEL CERCLA Disposal Facility Design Inventory, EDF-ER-264.

- Stanisich, N., D. Thorne, K. Roemer, S. McCormick, K. Martin, M. Lasky, J. Towers, 2001, Composite Analysis for Tank Farm Closure – Draft, INEEL-EXT-2000-01630, Portage Environmental, Inc., Prepared for the U. S. DOE-ID, April 2001.

- McCarthy, J. M., B. H. Becker, S. O. Magnuson, K. N. Keck, and T. K. Honeycutt, 2000, Radioactive Waste Management Complex Low-Level Waste Radiological Composite Analysis, INEEL/EXT-97-01113, September 2000.

- EDF-1962, 2001, Transport Simulation Approach for the Risk Assessment for Deactivation of INTEC Plant Building CPP-603, May 2001.

- Keck, K. N., and A. S. Rood, 2001, Calciner System Screening-Level Risk Assessment for Tank and Piping Residue, EDF-1939, March 2001.

- Rood, S. M., C. S. Smith, and A. S. Rood, 1996, Risk Assessment for the RCRA Closure for the Waste Calcining Facility, INEL-96/0041, Rev. 1, March 1996.

- Schafer, A. L., 2001, Evaluation of Potential Risk via Groundwater Ingestion of Potential Contaminants of Concern for the INTEC HLW-EIS, INEEL/EXT-2000-209-Rev.1, May 2001.

- Tetra Tech NUS, 2001, "Calculation Package for Appendix C.9 to the Idaho High-Level Waste and Facilities Disposition," Final Environmental Impact Statement, DOE/ID-10900, July 2001.

- DOE-ID, 2001, HWMA/RCRA Closure Plan for the Calciner System in the New Waste Calcining System at the Idaho National Engineering and Environmental Laboratory, DOE/ID-10801, April 2001.

- DOE, 2002, Idaho High-Level Waste & Facilities Disposition – Final Environmental Impact Statement, DOE/EIS-0287, September 2002.

- Irving, J. S., 1998, Preliminary Draft – Environmental Assessment and Deactivation Plan for Obsolete Spent Nuclear Fuel Processing, Storage, and Support Facilities at the Idaho Nuclear Technology and Engineering Center (INTEC), DOE-EA-1244, Sept. 1998 (unpublished).

Although there are many potential aquifer contamination sources at the INEEL, most of them are outside the area of influence of the predicted aquifer contaminant plumes from the ICDF landfill. Contaminant source sites and contaminants of potential concern were evaluated on the basis of (1) proximity of the source to the ICDF landfill, (2) source location with respect to the groundwater flow path that passes beneath the ICDF landfill, (3) risk estimates from the WAG RI/FS studies, and (4) CERCLA assumptions on the potential future risk posed by co-located facilities.

In order to develop the source term, the following two steps were necessary. First, identify the contaminants of concern (COCs) for the CA. Second, identify the sources of radioactive material in the ground that may contribute to the dose from the ICDF landfill received by a hypothetical future member of the public. Third, estimate a radionuclide source term (radionuclide inventory and release rate) for each source. The necessary information is presented in the following sections:

- Section 2.1—Define the contaminants of concern evaluated for this CA
- Section 2.2—Summarizes all of the potential INEEL source areas
- Section 2.3—Presents the sources that are included in the groundwater pathways analysis
- Section 2.4—Presents the sources at the INEEL that were evaluated and excluded in the ICDF landfill CA calculations
- Section 2.5—Presents the estimated radionuclide inventories and release rates used for the ICDF landfill CA source term.
- Section 2.6—A summary discussion of the ICDF CA inventories, source terms, and limitations.

2.1 Define the ICDF CA Contaminants of Concern

The COCs for this CA were chosen to be the groundwater pathway COCs identified in the ICDF Landfill PA (DOE-ID 2003a) (I-129, Np-237, Pu-239, Tc-99, U-234, and U-238) plus any COCs (at times past 1,000 years) identified by reviewing the reports on the predicted radiological doses and risks from other INEEL sources.

Since the ICDF landfill-related dose does not begin until 1,000 years in the future, the CA doses of interest also start in 1,000 years. This immediately excludes all radionuclides with decay half-lives of less than about 100 years. In particular, this eliminates as COCs H-3, Co-60, Cs-137, Pu-238, and Sr-90. Nuclides identified in other evaluations of INEEL sources that were not eliminated based on relatively short radioactive decay half-lives are Am-241, C-14, and Pu-240.

The ICDF landfill CA COCs are defined as Am-241, C-14, I-129, Np-237, Pu-239, Pu-240, Tc-99, U-234, and U-238. Inventories presented in Section 2.5 will be focused on these ICDF landfill CA COCs. References are provided to lead the reader to complete inventories if they are of interest.

2.2 Potential INEEL Sources Areas

The INEEL encompasses 2,305 km^2 (890 mi^2) with nine major facilities scattered across the site: Test Area North (TAN), Naval Reactors Facility (NRF), Test Reactor Area (TRA), Idaho Nuclear Technology and Engineering Center (INTEC) formerly known as Idaho Chemical Processing Plant (ICPP), Central Facilities Area (CFA), Power Burst Facility (PBF), Argonne National Laboratory-West (ANL-W), Experimental Breeder Reactor I (EBR-I), and Radioactive Waste Management Complex (RWMC) (see Figure 2-1). The distance between the ICDF landfill and the major INEEL facilities ranges from just a few kilometers to 35 km (22 mi) to the northeast (TAN) and 25 km (15 mi) to the east (ANL-W).

Under the CERCLA program, the INEEL is divided into waste area groups (WAGs) to facilitate environmental remediation efforts. WAGs 1 through 9 generally correspond to the INEEL operational facilities, while WAG 10 corresponds to overall concerns associated with the SRPA and those surface and subsurface areas not included in the bounds of the facility-specific WAGs.

TAN (WAG 1) is located at the north end of the INEEL, about 35 km (22 mi) northeast of the ICDF landfill at INTEC (WAG 3). TAN was established in the 1950s by the U.S. Air Force and Atomic Energy Commission Aircraft Nuclear Propulsion Program to support nuclear-powered aircraft research.

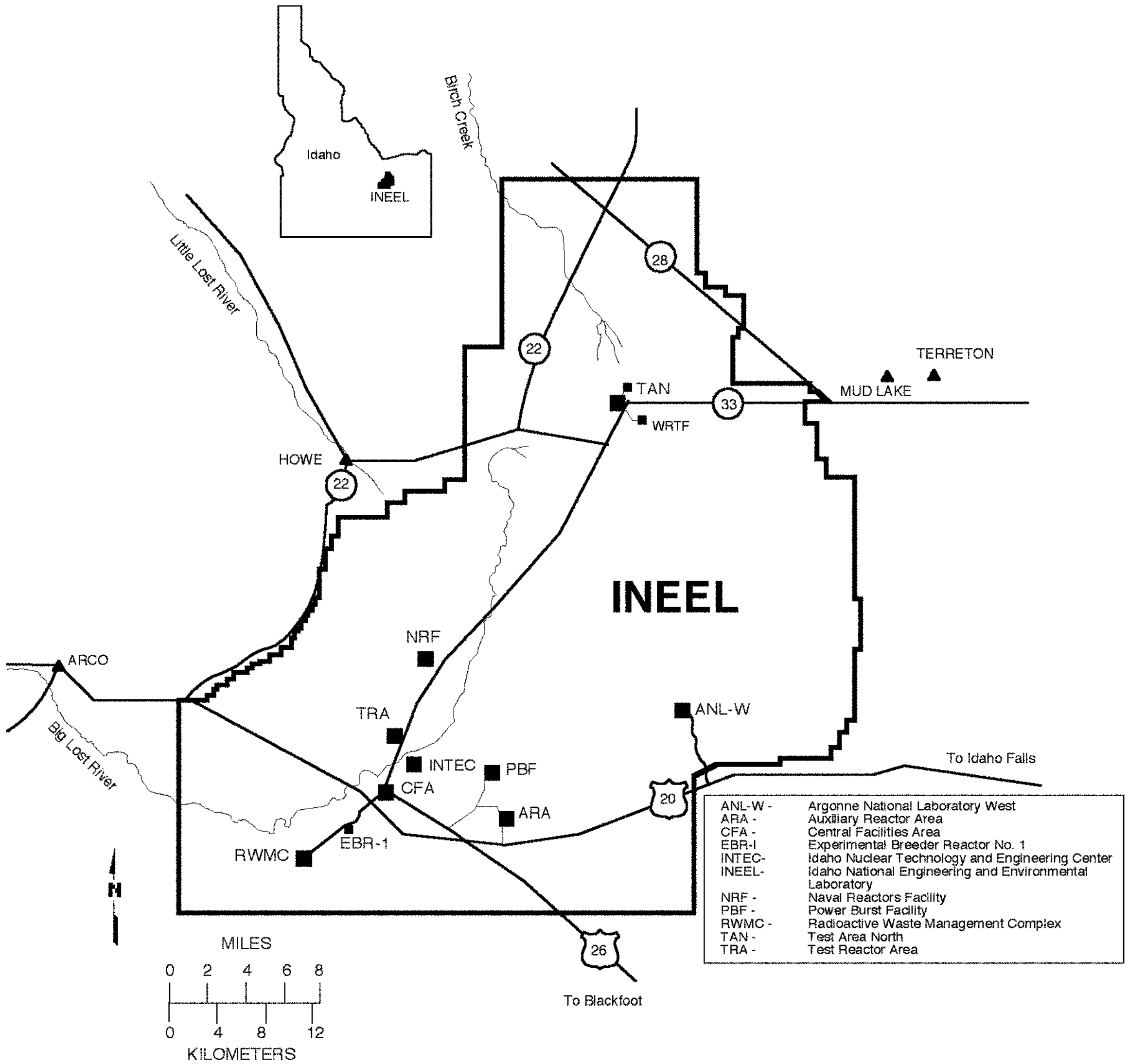

Figure 2-1. Map showing the location of facilities within the INEEL.

Upon termination of this research, the area's facilities were converted to support a variety of other DOE research projects. Environmental sites under investigation at TAN include an injection well, pits, rubble disposal sites, tanks, wastewater disposal ponds, burn pits, a sewage lagoon, and historic spill sites.

TRA (WAG 2) is located in the southwest portion of the INEEL, 3 km (2 mi) northwest of the ICDF landfill. The major mission of TRA is to conduct scientific and engineering experiments on behalf of DOE and to support various nuclear and nonnuclear programs. TRA was established in the early 1950s with the development of the Materials Test Reactor. Two other major reactors, the Engineering Test Reactor and the Advanced Test Reactor, were built soon after. The Materials Test Reactor was shut down in 1970, and the building is now used for offices, storage, and test areas in support of activities at INTEC. The Engineering Test Reactor has been inactive since January 1982. The major program at the area now is the Advanced Test Reactor. Sites being investigated at TRA include pits, tanks, rubble piles, ponds, cooling towers, wells, french drains, and spills. A comprehensive RI/FS for TRA has been evaluated under the CERCLA program and more detailed information about this facility may be found in Burns et al. (1997).

INTEC (WAG 3) is located adjacent to the ICDF. The mission of the plant is to receive and store spent nuclear fuels and radioactive wastes, treat and convert wastes, and develop new technologies for waste and waste management for the DOE. Before April 1992, this mission also included nuclear fuel reprocessing. However, reprocessing work was phased out, and, consequently, facilities once dedicated to reprocessing work will be converted to a safe and stable shutdown condition while awaiting reuse or decontamination and decommissioning. Sites being investigated at INTEC include facilities associated with wastewater disposal systems such as sumps, ponds, a disposal well, spills, and tank farm storage systems.

CFA (WAG 4) is located about 5 km (3 mi) south of the ICDF landfill and is the main service and support center for the programs located at the INEEL's other primary facility areas. Eighty percent of the activity at CFA consists of INEEL-wide programmatic support such as transportation, maintenance, capital construction, environmental and radiological monitoring, security, fire protection, warehouses, calibration laboratories, and a cafeteria. A small amount of research and development work is also conducted. Work on radioactive and hazardous materials is restricted in and around CFA. Sites under investigation at CFA include historical spills, tanks, landfills, ponds, leach fields, and leach pits.

PBF (WAG 5) is located in the south-central portion of the INEEL, about 5 km (3 mi) east of the ICDF landfill. PBF was established in the 1950s to test the operational behavior of reactors and to study the safety of light-water-moderated, enriched fuel systems. Now the mission of PBF is to become a regional and national center for hazardous waste reduction and mixed waste treatment, research, and development. Sites being investigated at PBF include evaporation ponds, percolation ponds, leach fields, pits, and dry wells. In conjunction with WAG 5 is the Auxiliary Reactor Area (ARA). ARA consisted of four separate groupings of buildings in which various activities have occurred including the operation of test reactors. All of the ARA reactors have been removed from the facility and have undergone partial or complete decontamination and decommissioning. Most of the radioactive materials were buried in a trench and are available for transport.

EBR-I (WAG 6) is located in the southwestern portion of the INEEL site, about 9 km (5.5 mi) southwest of the ICDF landfill. EBR-I was the first reactor built on the site and the first reactor in the world to generate electricity. It began operating on December 20, 1951. This reactor provided the first proof that nuclear fuel breeding (creating more fuel than is used) was feasible. It is no longer operational; however, it has become a National Historic Landmark. Also, within WAG 6 are the remains of the Boiling Water Reactor Experiment (BORAX) facilities. The BORAX-I reactor was a small experimental reactor used in the summer months of 1953 and 1954 for testing boiling water reactor technology. BORAX-I was designed to investigate the ability of the reactor to protect itself against sudden, artificially induced increases in reactivity. During the last test, the reactor was intentionally destroyed to determine its inherent safety under extreme conditions. Subsequent BORAX experiments, BORAX-II through V, were conducted from 1954 to 1964 152 m (500 ft) east of BORAX-I. Sites being investigated at WAG 6 include old tanks, a small spill area, and several liquid and solid waste disposal locations.

RWMC (WAG 7) is located in the southwestern portion of the INEEL site, about 16 km (10 mi) southwest of the ICDF landfill. The RWMC was established in 1952 and is a controlled area for the disposal of solid radioactive waste generated at the INEEL. The primary site being investigated under the CERCLA agreement is the Subsurface Disposal Area (SDA) within the RWMC, which includes pits, trenches, and vaults where radioactive and organic wastes were placed, with the exception of the active low-level radioactive waste storage area (Pits 17–20). The Transuranic Storage Area within the RWMC has been used since the early 1970s for retrievable storage of transuranic waste on earthen-covered pads and in facilities awaiting final shipment to the Waste Isolation Pilot Plant (WIPP). The Stored Waste Examination Pilot Plant is also located at the RWMC and is used for certifying waste destined for shipment to WIPP in New Mexico.

NRF (WAG 8), a part of the Bettis Atomic Power Laboratory, was established in the early 1950s to support development of naval nuclear propulsion. The facility is 10 km (6 mi) north of the ICDF landfill and is under the direct supervision of the DOE's Office of Naval Reactors. The facility supports the Naval Nuclear Propulsion Program by carrying out assigned testing, examination, and processing activities. Sites under investigation at NRF include landfills; old spills; wastewater disposal systems such as ponds, ditches, basins, drains, and drain fields; and storage areas.

ANL-W (WAG 9) is located in the southeastern portion of the INEEL site, about 26 km (16 mi) northeast of the ICDF landfill. ANL-W is the prime testing center in the U.S. for advanced reactor systems research. Research centered on the Experimental Breeder Reactor II that operated from 1964 to 1994. Along with the reactor's research contributions, it produced electrical power with an electrical output of 19.5 MW of electricity. The reactor is currently being defueled for decommissioning. Sites being investigated at ANL-W include tanks and wastewater handling and disposal systems.

2.3 Sources Included in the Groundwater Pathways Analysis

As explained above, sources included in this ICDF landfill CA are chosen based on proximity to the ICDF landfill and the aquifer flow lines that pass through the vicinity of the ICDF landfill. The CA superimposes the predicted contaminant concentrations from included sources onto the predicted contaminant concentrations from the ICDF landfill PA. The sources included in this ICDF landfill CA are listed below and are described in this section. The locations of the sources included are shown in Figure 1-2. These sources include

- ICDF landfill
- INTEC Tank Farm Facility closure action residuals
- INTEC bin sets
- INTEC CERCLA contaminated soils sites
- INTEC disposal well
- Waste Calcining Facility (WCF)
- New Waste Calcining Facility (NWCF)
- Process Equipment Waste Evaporator (PEWE)
- Fuel Processing Complex, CPP-601
- Fuel Receipt and Storage Facility, CPP-603.

Note that all the CA sources are within the boundaries of the INTEC. Sources at the INEEL that do not contribute to the aquifer dose from the ICDF landfill are discussed in Section 2.4. Inventories and source release functions for all included sources are given in Section 2.5.

2.3.1 ICDF Landfill

According to the OU 3-13 ROD (DOE-ID 1999), the ICDF landfill has an authorized capacity of 389,000 m^3 (510,000 yd^3). Approximately 358,903 m^3 (469,400 yd^3) of INEEL CERCLA remediation waste, about 92% of the authorized capacity, have already been identified for disposal in the ICDF landfill during the first 10 years of operation. This remediation waste includes 304,846 m^3 (398,700 yd^3) of predominately contaminated soils with minor debris and 54,057 m^3 (70,700 yd^3) of debris from DD&D activities. Only DD&D activities from CERCLA actions will be disposed of to the ICDF landfill. In addition to remediation waste, an additional 61 m^3 (80 yd^3) of IDW generated as part of the OU 3-14 tank farm investigation will be disposed in the ICDF landfill.

Any soil treatment will occur at the SSSTF, which is a part of the ICDF Complex. The majority of wastes (primarily soils) that would be processed through the facility and designated option paths for these wastes have been identified (EDF-ER-296).

A small fraction of the waste is already in metal containers. However, for the PA analyses, as well as this CA analysis, it is assumed that the entire waste is compacted soil. This is a conservative assumption with respect to the leaching of contaminants from the facility.

There are relatively few uncertainties related to the media of the waste to be disposed of to the ICDF landfill. The waste will be predominantly soils that will be compacted during emplacement in the facility. All containerized and grouted wastes should be more stable than the compacted soil. Therefore, treating the waste as 100% compacted soil is a conservative assumption. There is relatively large uncertainty in the radionuclide inventory contained in the soils. As will be explained below, the total inventory was conservatively estimated in order to compensate for this uncertainty.

A detailed discussion of the ICDF landfill is presented in the ICDF PA (DOE-ID 2003a), which is a companion document to this CA.

2.3.2 INTEC Tank Farm Facility Closure Action Residuals

From 1952 to 1991, the DOE processed spent nuclear fuel at INTEC. The process was designed to recover the highly enriched uranium in the fuel and used a three-step solvent extraction process. The first solvent extraction cycle resulted in a highly radioactive liquid that was considered high-level waste (HLW) and stored at the Tank Farm Facility (TFF). Subsequent extraction cycles and decontamination activities generated a liquid waste that was concentrated by evaporation and stored at the TFF in belowgrade tanks. The tanks are made of stainless steel and contained in a concrete vault. In addition to the waste generated by processing spent nuclear fuel, newly generated low-level liquid waste has been evaporated and added to these belowgrade tanks. This additional waste is from processes and decontamination activities at INTEC facilities not associated with the HLW program and from other INEEL facilities.

Under terms of a 1998 modified consent order, DOE must permanently cease use of tanks in the Tank Farm Facility or bring the tanks into compliance with secondary containment requirements as set forth by IDAPA 58.01.05.009 (40 CFR 265.193). The consent order further specifies that this compliance cannot be achieved through an equivalency demonstration or by obtaining a variance as provided by IDAPA 58.01.05.009. DOE has decided to close the TFF because high radiation fields would make compliance with secondary containment requirements difficult. The TFF is being closed under DOE Order 435.1 as is the ICDF landfill.

The TFF closure action residuals contain a significant inventory and are in the proximity of the ICDF landfill. Therefore, they are included as a source in this ICDF landfill CA.

2.3.3 INTEC Bin Sets

From December 1963 to May 2000, fluid-bed calcining had been used at INTEC to convert aqueous wastes to granular solids. The wastes were processed in a heated fluidized-bed calciner to metallic oxides or fluorides, water vapor, and nitrogen oxides. The solids are transported to stainless steel bins (called the bin sets) for interim storage. Detailed operational chronologies for the various calcination campaigns are presented by Staiger (1998).

The decontaminated bin sets were evaluated in the HLW Environmental Impact Statement (EIS) (DOE 2002) and in the CA for the INTEC TFF closure (DOE-ID 2002d).

The bin sets are assumed to contain a significant inventory and are in the proximity of the ICDF landfill. Therefore, they are included as a source in this ICDF CA.

2.3.4 INTEC CERCLA Contaminated Soils Sites

The INTEC CERCLA contaminated soils were evaluated in the INTEC Comprehensive RI/FS (DOE-ID 1997). The contaminated soils are distributed throughout INTEC but the majority of the contamination is focused in the area of the tank farm. The soil sources can be divided into three main categories: (1) soils contaminated from known tank farm area releases, (2) all other soil contamination that is distributed throughout the area of INTEC, and (3) contaminants disposed of to the service waste ponds (also know as the percolation ponds). For a detailed description, see the INTEC comprehensive RI/BRA (DOE-ID 1997). The CERCLA contaminated soil sites have been shown to contain a significant inventory and are in the proximity of the ICDF. Therefore, they are included as a source in this ICDF CA. The estimated inventory and a discussion of the release rates and a revised inventory for the tank farm soils are provided in Section 2.5.

2.3.5 INTEC Disposal Well

A total of 4.2×10^{10} L (1.1×10^{10} gal) of water and 22,200 Ci of mainly H-3 and Sr-90 were disposed of to the INTEC disposal well between 1953 and 1986. See Section 9.2 in the comprehensive RI report (DOE-ID 1997) for a complete discussion of past disposals to the well. Although the time frame of contamination from the disposal well is quite different than radionuclide transport from the ICDF landfill, based on proximity, it is possible that there will be some cumulative effect of contamination in the aquifer from contaminants at the ICDF landfill and contaminants released to the INTEC disposal well. Therefore, the INTEC disposal well was included in the CA as a source of potential concern. The estimated inventory and a discussion of the release rates are provided in Section 2.5.

2.3.6 Waste Calcining Facility

The Waste Calcining Facility (WCF) at the INTEC was designed to achieve safe and efficient treatment of high-level radioactive waste from the reprocessing of spent nuclear fuel. The WCF began operation in 1963 and ceased calcining operations in 1981. Because of the deteriorating condition of the WCF calciner, it was replaced by a new calciner at the New Waste Calcining Facility (NWCF). The WCF evaporator and associated tanks were used until the spring of 1987 and then placed in a standby condition.

The WCF was a heavily reinforced concrete structure with approximately 1,900 m^2 (20,000 ft^2) of floor space involving a ground level and two levels belowgrade, within a 21- × 34-m (70- × 100-ft) footprint. The design and operation of the WCF utilized lead shielding to protect workers from the high radiation fields. This shielding is located inside the cell walls or in areas heavily contaminated with radionuclides.

The WCF converted high-level radioactive liquid wastes into granular solids that were less corrosive, less mobile, and occupied less storage volume. Waste from reprocessing spent nuclear fuels was sprayed into a hot, air-fluidized bed of granular solids. Water flashed off the metallic salts, which were converted to their corresponding oxides and fluorides. This process converted more than 15 million liters (4 million gallons) of aqueous liquid waste into approximately 2,000 m^3 (77,000 ft^3) of a dry, solid waste, presently stored in Bin Sets 1, 2, and 3 located southeast of the WCF. After the final shutdown of the WCF, the system was flushed out and only process residues, silica gel, and structural elements (such as asbestos) remained as potential contaminant sources in the facility.

As part of the closure of the WCF, the following steps were taken:

- All piping that was outside the footprint of the landfill cap and contained residual contamination were flushed and the pipes were filled with grout.
- The belowgrade portion of the facility was filled with grout.
- All of the aboveground structures were demolished and left abovegrade with an approximate 0.3-m (1-ft) concrete cap placed over them. In addition, concrete was poured over the rubble to fill any void spaces.
- The WCF was HWMA/RCRA closed as a landfill.

No significant risk was identified, but because the WCF is very near the other sources in this CA, it is included as a possible contributing source to the overall dose. The estimated inventory and a discussion of the release rates are provided in Section 2.5.

2.3.7 New Waste Calcining Facility

The calciner system in the NWCF is inactive and a RCRA closure plan has been submitted for facility closure (DOE-ID 2001b). The anticipated HWMA/RCRA closure of the NWCF (CPP-659) is as a RCRA landfill. This includes the Hepa Filter Leach System and other RCRA units in CPP-659.

The risk assessment analysis of the NWCF was a screening level analysis. Conservative assumptions were made on the radionuclide inventory that would be left in the facility. No significant risk was identified, but because the NWCF is very near the other sources in this CA, it is included as a possible contributing source to the overall dose. The estimated inventory and a discussion of the release rates are provided in Section 2.5.

2.3.8 Process Equipment Waste Evaporator

The Process Equipment Waste Evaporator (PEWE) building (CPP-604) is a 2,255-m^2 (24,275-ft^2) multi-level, steel frame and reinforced concrete building. The primary function of the PEWE is to separate liquid radioactive waste into two fractions. The high-level waste is directed to the tank farm. The other fraction is directed to the Liquid Effluent Treatment and Disposal Building.

According to the HLW&FD EIS (DOE 2002), the Process Equipment Waste complex is targeted for a landfill closure, except for the Liquid Effluent Treatment and Disposal Building (CPP-1618), which would be targeted for clean closure. The belowground levels of the complex would be grouted with concrete. Subsequently, the aboveground portion would be demolished in place and covered with an earthen cap. Complete deactivation of the complex would be completed in 2037. Demolition would start in 2038 and be completed in 2043.

No significant ICDF CA dose contribution is expected from the PEWE, but because the PEWE is very near the other sources in this CA, it is included as a possible contributing source to the overall dose. The estimated inventory and a discussion of the release rates are provided in Section 2.5.

2.3.9 Fuel Processing Complex, CPP-601

The radionuclides expected to be left in the CPP-601 facility were evaluated in a preliminary draft environmental assessment.[c] The EA treats CPP-601, -627, and –640 as an integral unit called the CPP-601 complex. This EA has not been submitted for public comment.

The CPP-601 facility contains chemical processing equipment used to recover uranium from various types of nuclear fuel.[c] The facility is essentially rectangular (74 × 31 m [244 × 102 ft]) and consists of five levels (up to 30 m [95 ft] high, mostly belowground). The top level is abovegrade and contains an open area that workers used to transfer fuel elements to the process equipment and for chemical storage, makeup, and transfer. The lower levels are largely belowground and are constructed of reinforced concrete with walls up to 1.5 m (5 ft) thick.

The lower levels contain 29 process cells (most of which are about 6 m square and 8.5 m high [20 ft square and 28 ft high]), numerous corridors, and auxiliary cells that house equipment and controls. The largest cell is approximately 18 m × 6 m × 12 m (60 ft × 20 ft × 40 ft) high. Stainless steel lines the floor and part of the walls of each cell and most of the equipment is stainless steel. Most of the processing equipment in the building is in the heavily shielded cells, designed for remote operations.

CPP-627 is entirely aboveground and constructed of reinforced concrete and masonry block. This facility was used for small-scale custom dissolution processes and included the Hot Chemistry Laboratory, Shift Lab, Remote Analytical Facility, Multi-Curie Cell, and the Decontamination Support Facility. CPP-627 was constructed in 1955. CPP-627 is deteriorating and DOE is not considering it for future operation or reuse.

CPP-640 is the Headend Processing Plant. It houses two unique spent fuel headend processing systems and a liquid waste collection system. The headends operated in heavily shielded concrete and steel hot cell units with remote manipulation and some remote maintenance capabilities. The liquid waste collection system includes three tanks in heavily shielded concrete vaults situated below the hot cell units. DOE constructed the two processing systems in 1961 and shut down one of the processes in 1981 and the other in 1984.

The government constructed the building in 1953. DOE ended nuclear fuel reprocessing at CPP-601 in 1992 and the facility was no longer needed, making the facility obsolete for the originally intended mission. The facility is in surveillance and maintenance status until DOE decides to convert it to a new use or to dismantle it. Portions of the systems within CPP-601 will be RCRA closed under the Voluntary Consent Order.

The risk assessment for the environmental assessment includes estimates for the radionuclide inventory to be left in CPP-601.[c] Because the facility is at INTEC, close to the tank farm area, and

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c. Personal communication between J.M. McCarthy, BBWI, and J. S. Irving, BBWI, August 21, 2003, regarding unpublished document, "Preliminary Draft—Environmental Assessment and Deactivation Plan for Obsolete Spent Nuclear Fuel Processing, Storage, and Support Facilities at the Idaho Nuclear Technology and Engineering Center (INTEC)," DOE-EA-1244, U.S. Department of Energy Idaho Operations Office, September 1998.

contains a significant inventory, it could contribute to the cumulative dose from the ICDF landfill. The estimated inventory and a discussion of the release rates are provided in Section 2.5.

2.3.10 Fuel Receipt and Storage Facility, CPP-603

CPP-603 was constructed in 1953 and contains two primary spent nuclear fuel facilities. They are the Fuel Receiving and Storage Facility (FRSF) and the Irradiated Fuel Storage Facility (IFSF). The FRSF contains three underwater fuel storage basins. This portion of CPP-603 was used to receive, unload, and provide underwater storage for fuel. The Fuel Element Cutting Facility (FECF) is in the FRSF portion of the building. FECF is a hot cell previously used for cutting fuel. Included at INTEC-603 is SFE-106, the Radioactive Solids and Liquid Waste Storage Vessel.

The CPP-603 underwater storage basins began operation in 1953. DOE has completed operations at the basins and is in the process of decontamination. The current plan is to remove much of the contaminated soils and grout the basins. The inventory is presented in Section 2.5.

2.4 Sources Excluded in the Groundwater Pathways Analysis

Although there are many potential aquifer contamination sources at the INEEL, the spatial separation of the contaminant sites results in very little overlapping of contaminant plumes. Most of the plumes cannot and will not significantly influence the groundwater dose downgradient from the ICDF landfill. Contaminant source sites and contaminants of potential concern were evaluated on the basis of (1) proximity of the source to the ICDF landfill, (2) source location with respect to the groundwater flow path that passes beneath the ICDF landfill, (3) risk estimates from waste area group RI/FS studies, and (4) CERCLA assumptions on the potential future risk posed by co-located facilities.

This section shows (1) the scale of current contaminant plumes from the disposal wells, (2) most of the INEEL sources can be excluded from interacting with the ICDF plumes based on their regional and intermediate scale flow paths in the aquifer, and (3) the lack of significant predicted aquifer concentrations from other sources allows them to be excluded from the analysis. The following is an outline of the section:

- Section 2.4.1—Summary of the INEEL radionuclide contaminant plumes
- Section 2.4.2—Excluded sources outside the regional scale groundwater flow corridor
- Section 2.4.3—Exclude RWMC as a contributor to the ICDF landfill cumulative dose
- Section 2.4.4—Excluded sources within the upgradient flow corridor
- Section 2.4.5—Excluded sources within the downgradient flow corridor.

2.4.1 Summary of INEEL Radionuclide Contaminant Plumes

Figure 2-2 is provided to show the extent of measured contaminant plumes in the aquifer above a dose level of 0.5 (yellow shading) and 4 mrem/yr (red shading). These aquifer plumes are interpolated from 1998 data of H-3 and Sr-90 concentrations (McCarthy et al. 2000).

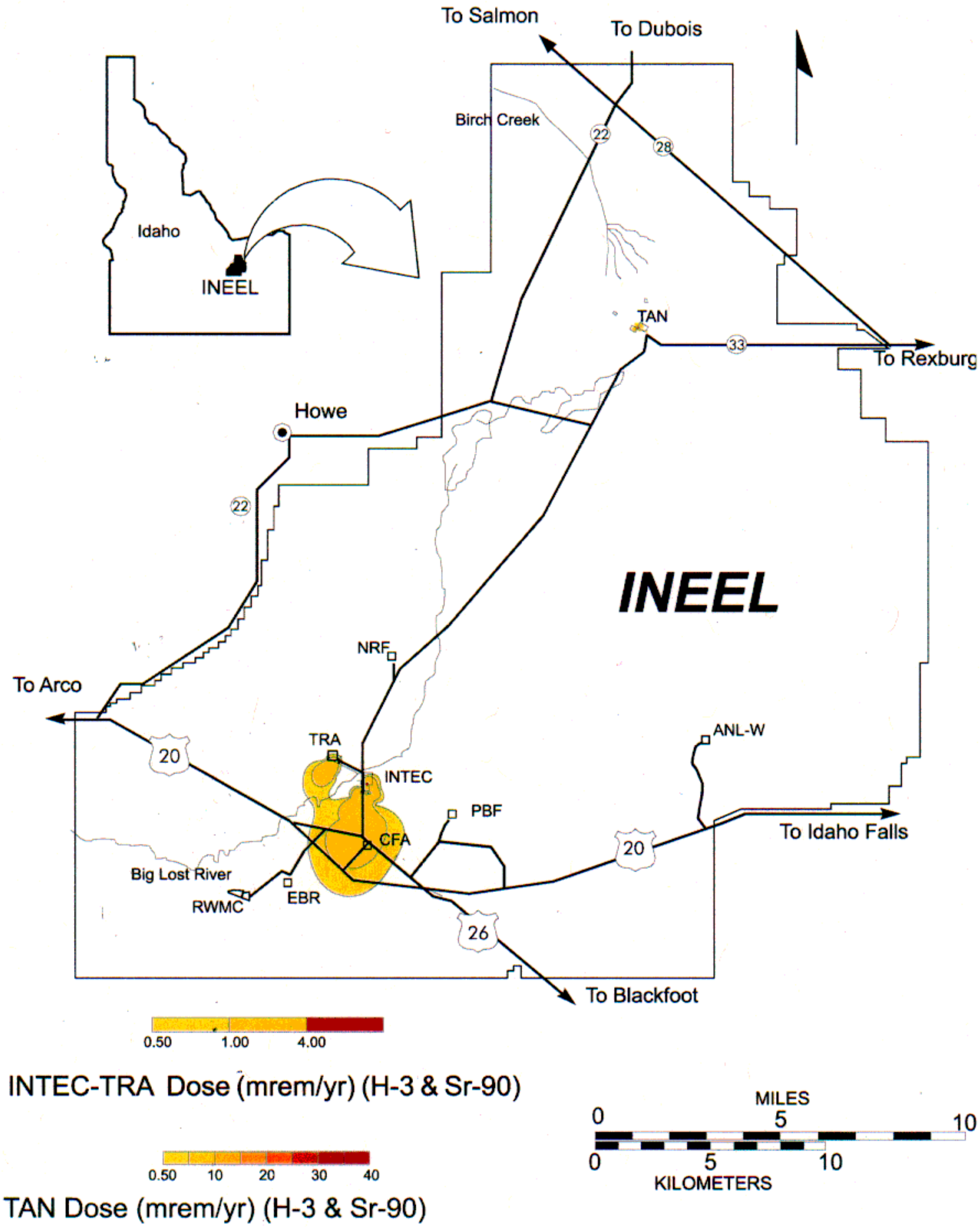


Figure 2-2. Extent of 1998 aquifer contamination at the INEEL.

The dose contours shown in Figure 2-2 are scaled differently for the INTEC and TRA area than the TAN area. In the INTEC and TRA area, there is a very small area with H-3 and Sr-90 concentrations corresponding to a cumulative dose of more than 4 mrem/yr. There is a rather large area with concentrations corresponding to 0.5 and 1 mrem/yr. Both H-3 and Sr-90 contribute to the dose between the INTEC and CFA. Outside of the INTEC-CFA corridor, the dose is primarily from the H-3 in the aquifer. In the TAN area, there is a very small area with concentrations corresponding to a dose of 0.5 mrem/yr and an even smaller area with concentrations corresponding to a dose of 40 mrem/yr. This dose is primarily from the Sr-90 and is concentrated around a former disposal well. The disposal well received treated sanitary sewage, industrial wastewater, and low-level radioactive waste until 1972. Occasional disposals to the well may have continued until the early 1980s. Concentrations as high as 2,000 pCi/L (230 mrem/yr all-pathways dose) were measured at ANP 3 (TAN disposal well) in the late 1980s (McCarthy et al. 2000). Pump and treat has been used to remove some of the sludge in the aquifer at the disposal well; however, the Sr-90 concentrations remain high.

The dose contours shown in Figure 2-2 are based on H-3 and Sr-90 concentrations because these are the only radionuclides with sufficiently complete data sets in 1998. The radionuclides Tc-99, Cs-137, Np-237, and I-129 could be contributing to the dose plumes but there is insufficient data to quantify the contribution. The contribution from the additional four is expected to be minor overall, but could be significant in the vicinity of the ICDF landfill and INTEC.

2.4.2 Excluded Sources Outside the Regional Scale Groundwater Flow Corridor

The source terms of interest are the buried wastes at the INTEC and any upgradient or downgradient radiological sources with a potential for generating a contaminant plume in the groundwater that may interact with a plume originating at the ICDF landfill. Since the ICDF landfill is a small part of the INTEC, the following discussions will focus on the source locations with respect to INTEC. All potential radiological sources are within the boundaries of the INEEL. Ingestion of contaminated groundwater is the recognized exposure pathway of primary concern. Therefore, this study focuses on those radiological source terms in the ground that may enhance effective dose equivalents (EDEs) due to concentrations of radionuclides in the groundwater.

The probability that source terms will interact is directly correlated to their proximity to the ICDF landfill and location relative to aquifer flow lines. A preliminary screening on the basis of location without regard to source term characteristics was performed to eliminate the detailed evaluation of source terms with little or no probability of interaction. Some facilities were eliminated in this section of the CA on the basis of location relative to the INTEC and groundwater flow direction at the INEEL scale.

A series of groundwater streamtubes (area between two streamlines) were constructed using a regional scale groundwater hydraulic head map (Figure 2-3). This figure illustrates that at the regional scale, the groundwater flows predominantly from northeast to southwest. The facilities PBF, ARA, ANL-W, and TAN are clearly outside any regional scale streamtubes passing near the INTEC. Therefore, these facilities are excluded from further consideration in the ICDF landfill CA. In the vicinity of the INTEC and south to CFA, the aquifer data indicate that the groundwater flows predominantly to the south.

Facilities evaluated further include INTEC, TRA, NRF, CFA, and BORAX. As discussed below, each of these facilities has completed or is currently in the process of CERCLA RI/FS evaluations that define the potential for groundwater contamination from each facility.

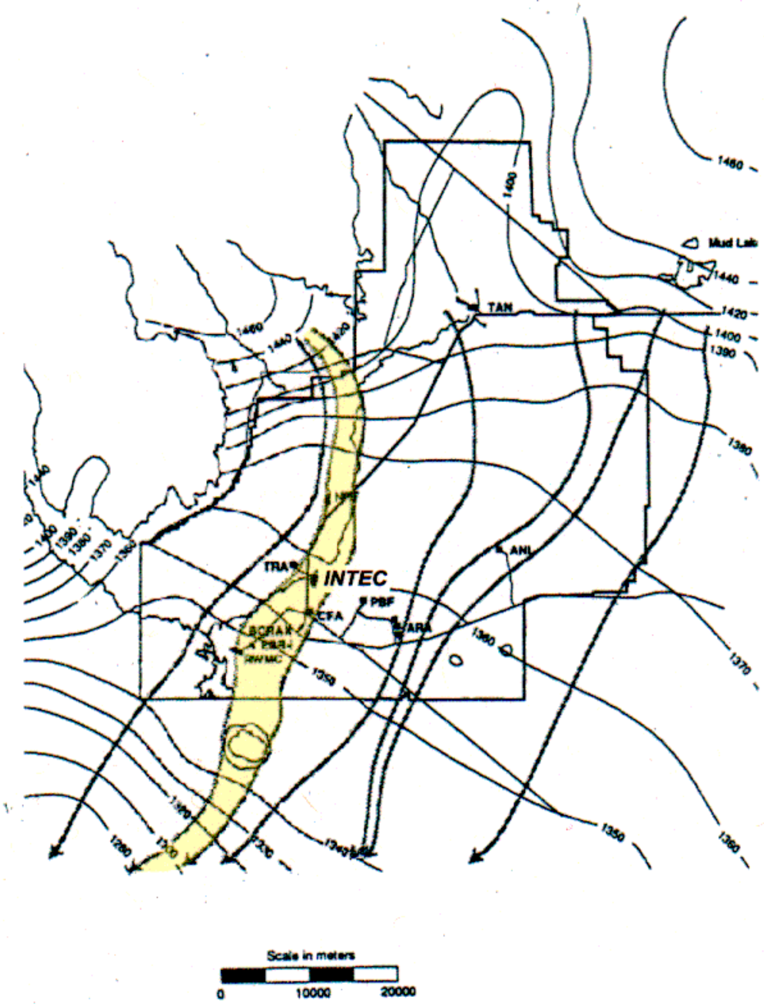


Figure 2-3. Groundwater flow paths at the INEEL.

2.4.3 Exclude RWMC as a Contributor to the ICDF Landfill Cumulative Dose

This section presents analyses that show that the RWMC is not downgradient of the INTEC and future ICDF landfill plumes.

The RWMC CA (McCarthy et al. 2000) contains an extensive discussion on the analyses of groundwater flow directions in the vicinity between the INTEC, TRA, CFA, and the RWMC. In this document, the discussion is summarized. The INTEC and RWMC plumes are shown to be separate by presentation of the INTEC disposal well H-3 plume and environmental isotope analyses.

2.4.3.1 Evaluation of the H-3 Plume. Previous interpretations of groundwater flow directions and contaminant monitoring data in the southern portion of the INEEL have inferred that the RWMC is downgradient of the INTEC facility (with respect to groundwater flow), or at least within the boundaries of contaminant plumes emanating from INTEC and TRA. These interpretations are primarily based on gradients inferred from large-scale water table maps and tritium monitoring data in Barraclough et al. (1981), Lewis and Jensen (1984), and Pittman et al. (1988). Aquifer monitoring wells immediately north and east of the RWMC (production well, USGS-87, and USGS-90) have consistently measured tritium at a level of approximately 1,000 to 2,000 pCi/L since the wells were installed in 1973.

Contour maps of tritium concentrations have been drawn that subjectively stretch westward to include these three RWMC monitoring wells even though water samples from the EBR-I well, which is included inside this “plume,” always show either very low tritium concentrations or nondetects. Figure 2-4 is reproduced from Barraclough et al (1981) and is the most extreme example of this “stretched” interpretation. Figure 2-4 may have served to set a precedent for the interpretations that followed in Lewis and Jensen (1984) and Pittman et al. (1988). In these interpretive contour maps, one of the justifications for ignoring the nondetection of tritium at EBR-I well is the assumption that water samples from that well are not considered to be representative of the upper portion of the aquifer. Well EBR-I is open from 24 to 146 m (79 to 479 ft) below the water table.

The tritium plume delineation is not definite; however, an alternative interpretation of tritium in the aquifer in the southern part of the INEEL suggests inadequate well control between RWMC and TRA/INTEC. Interpretation of 1992 tritium monitoring data indicates there were two separate tritium plumes in the southern portion of the INEEL: one co-mingled plume from INTEC/TRA and one distinct plume at the RWMC. This alternate interpretation treated the tritium nondetection at EBR-I with equal weight to other data points and contoured two distinct plumes.

Two separate additional lines of evidence are now available that support the alternative interpretation of a separate tritium plume at the RWMC. The first is additional monitoring data from a series of four wells installed in 1998 north and northeast of the RWMC. These wells are called M11S, M12S, M13S, and M14S and can be found in Figure 2-5, which shows contours of tritium data from the spring of 1998. These additional monitoring wells are completed with 6-m (20-ft) screens near the top of the aquifer, similar to the majority of aquifer monitoring wells in the RWMC vicinity. Since monitoring began in these four wells in 1998, tritium has been consistently detected in Wells M12S and M14S at levels ranging from 1,000 to 2,000 pCi/L. In the six rounds of quarterly sampling in Wells M11S and M13S, however, tritium has never been detected. Additionally, carbon tetrachloride has been detected in M14S in four out of six of these quarterly sampling events. The carbon tetrachloride in M14S is thought to be from the RWMC. By association then, the tritium in M14S could also likely have come from the RWMC. The nondetects in Wells M11S and M13S give strong credence to the presence of two distinct tritium plumes.

The second line of evidence that supports the alternative hypothesis of separate tritium plumes in the southern part of the INEEL is the results of an Environmental Management Science Program study that used isotopic ratios to delineate fast-flow pathways in the aquifer. This collaborative effort between INEEL, Los Alamos National Laboratory, and the University of Illinois at Urbana-Champaign has sampled wells and performed detailed analyses of naturally occurring strontium and uranium isotopes from a wide set of aquifer monitoring wells on and in the vicinity of the INEEL. Figure 2-6 is taken from Johnson et al. (1997) and shows interpreted fast flow paths within the aquifer. Based on uranium isotope ratios, the lighter shaded areas in the figure indicate more stagnant zones that have slower water velocities while the darker blue shaded areas indicate those regions that have higher flow velocities. One of these fast flow paths indicates an effect from the Little Lost River drainage that extends southward, and perhaps even a little eastward from the INTEC facility. Based on the fast flow path study results, the aquifer beneath the RWMC is interpreted to lie within a zone that is stagnant by comparison. The isotopic information from the fast flow path delineation study therefore supports the contention that the RWMC does not lie within a portion of the aquifer that is affected by discharges at INTEC.

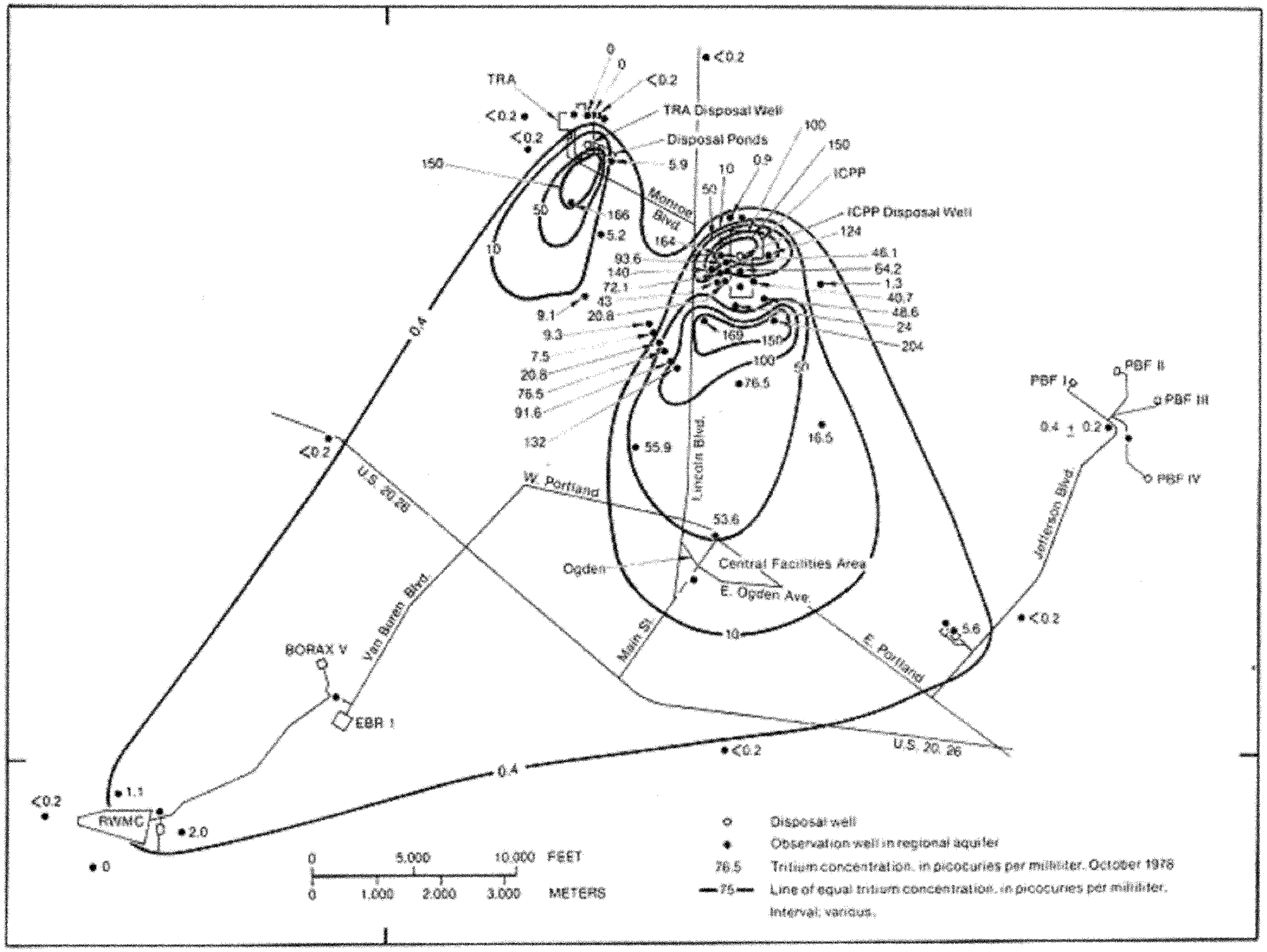


Figure 2-4. Historical interpretation of tritium plume in southern portion of the INEEL.

Tritium Contours - Spring 1998 (pCi/L)

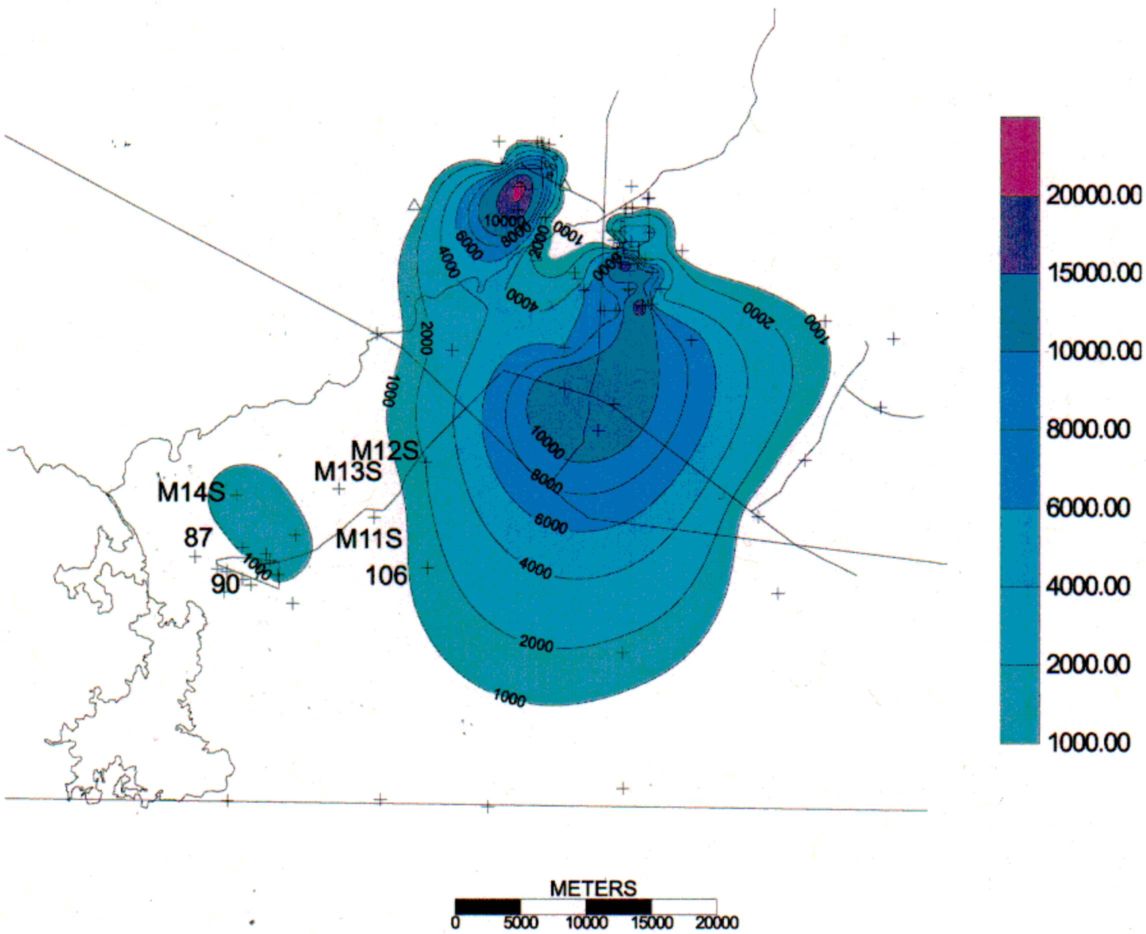


Figure 2-5. Interpreted tritium plumes based on 1998 tritium monitoring data.

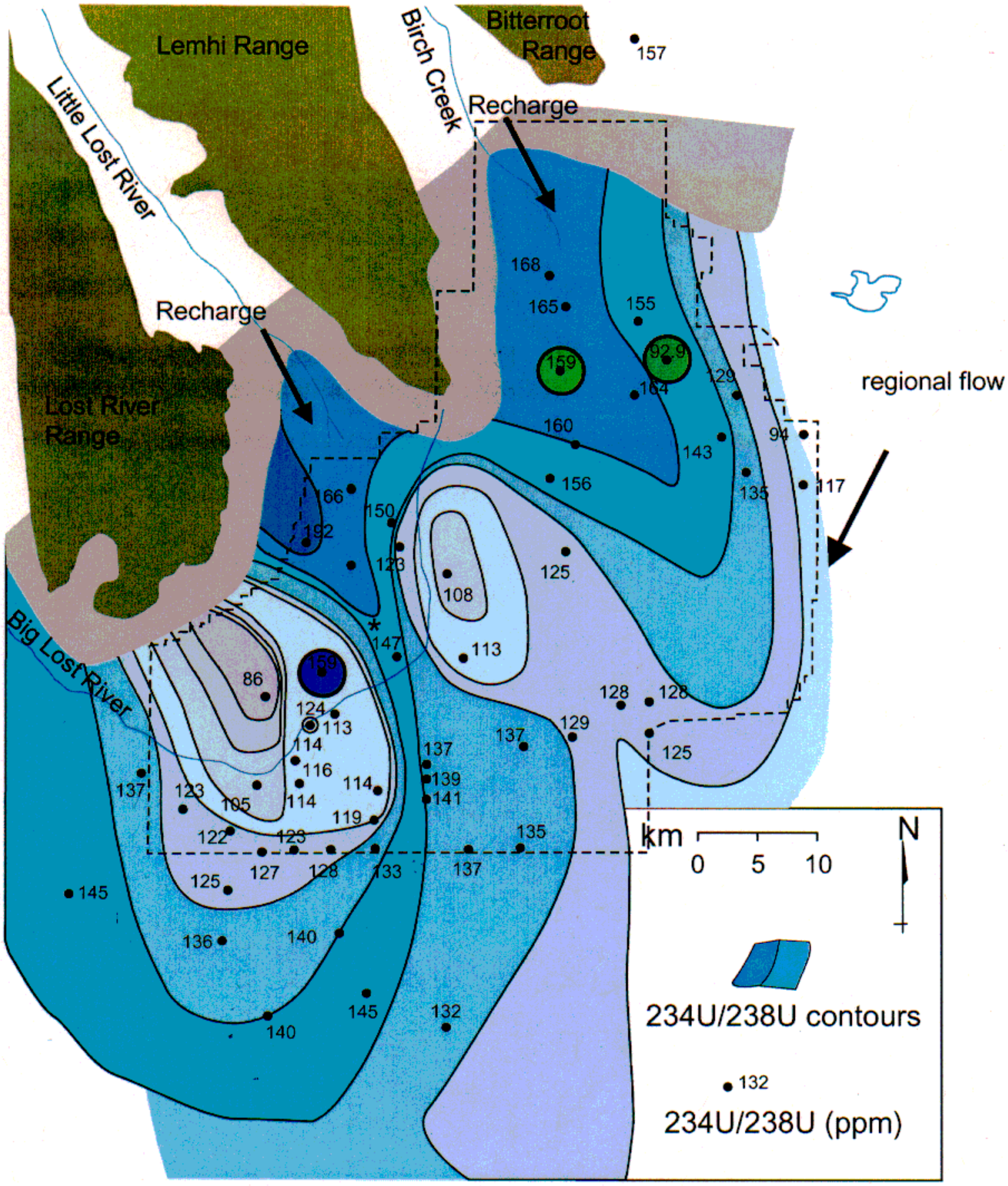


Figure 2-6. Interpreted fast flow pathways in the aquifer based on naturally occurring uranium and strontium isotopes in the vicinity of the INEEL (taken from Johnson et al. 1997).

In addition to these two lines of evidence, the regression analysis shown in Figure 2-7 indicates statistically different trends in observed concentrations in wells that consistently show tritium near the SDA (USGS-90 and M7S) and a well that is generally accepted to be within the tritium plume that emanated from TRA/INTEC (USGS-106). The locations of these three wells are indicated on Figure 2-5. Figure 2-7 shows tritium monitoring time series data from these wells. For USGS-90, the time series was plotted beginning in 1980 to be consistent with Well USGS-106, even though monitoring data for USGS-90 began in 1973. Each time series plot has both a linear trend line fitted to the data with the slope and P-value indicated to the right of the charts and a pure tritium decay curve (pink line) based on the 12.3-year half-life of tritium. The tritium decay line is initiated from the start of the linear trend line. The P-values are useful because, if they are less than 0.05, they indicate statistical confidence at the 2σ level that a trend is present. USGS-90 shows a slight downward trend that is statistically significant but it does not come close to matching the decay due to the tritium half-life. M7S does not show a statistically significant downward trend and because of the shorter monitoring period, does not look that different from the tritium decay curve. USGS-106 shows a strong statistically significant downward trend that closely matches a tritium decay line. What can be interpreted from this result is that the tritium in the aquifer at USGS-106 shows the effect of a receding plume that originally emanated from TRA/INTEC. Tritium monitoring in Wells USGS-90 and M7S do not show the receding trend that is evident at USGS-106. Rather, they indicate some other continued source of tritium. This is taken as further evidence of the likelihood that the tritium in the aquifer at the RWMC represents a distinct plume that is separate from the TRA/INTEC plume.

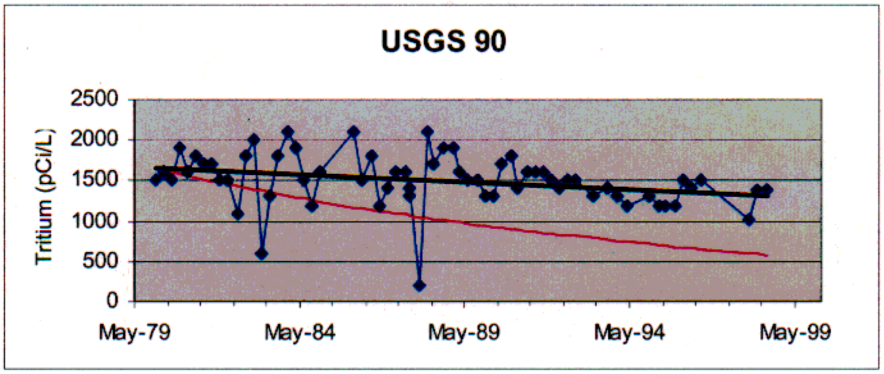
In summary, there is a substantial and growing body of evidence that indicates that waters in the Snake River Plain Aquifer beneath the RWMC are not influenced by contaminants introduced into the aquifer at TRA or INTEC. Previous interpretations to this effect are being supplanted with an interpretation based on a distinct plume from the RWMC because of additional monitoring data and isotopic studies. The interpretation based on current information is that the RWMC is far enough to the west that it appears to be off-gradient and out of the boundaries of any plumes emanating from TRA/INTEC.

2.4.4 Excluded Sources Within the Upgradient Flow Corridor

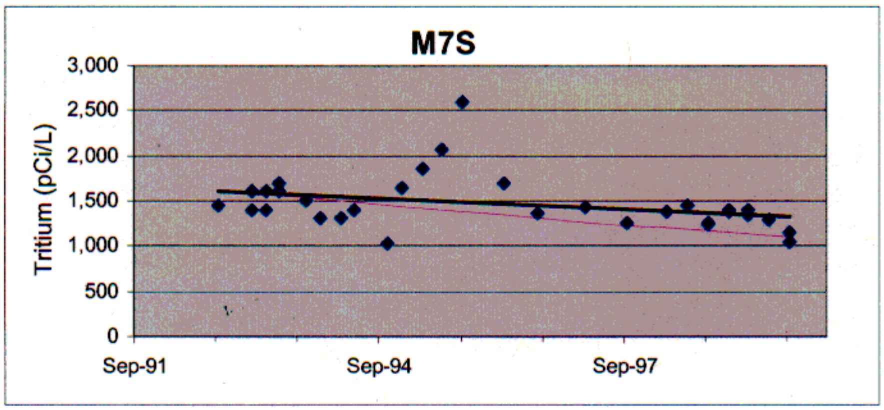
The results of the RI/FS studies for remaining facilities (TRA, NRF, BORAX, CFA, and INTEC) in the upgradient corridor, as defined in Section 2.2, are summarized below. Where the CERCLA evaluation has not shown any significant risk to the aquifer, the respective facility is then assumed to not contribute to the dose from the ICDF landfill. However, if the CERCLA evaluation does indicate a groundwater risk, then the predicted dose is calculated and evaluated as a possible dose contributor for the groundwater pathway.

2.4.4.1 Test Reactor Area Contribution to the ICDF Landfill Cumulative Dose. Potential release sites investigated under CERCLA at TRA (WAG 2) include pits, tanks, rubble piles, ponds, cooling towers, wells, french drains, and spills. A comprehensive RI/FS for TRA has been evaluated under the CERCLA program and more detailed information about this facility may be found in Burns et al. (1997).

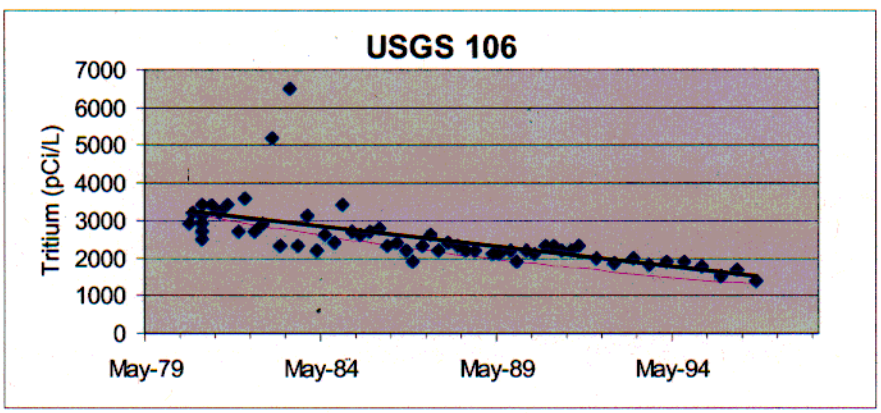
Tritium is the principal groundwater radionuclide of concern beneath TRA and has been detected in some TRA wells above its maximum contaminant level (MCL). Groundwater modeling indicates tritium contamination in the SRPA beneath TRA will naturally be reduced to concentrations below the MCL through radioactive decay and downgradient transport. Tritium concentrations are expected to fall below the MCL by the year 2004 and will not present an unacceptable risk to potential future groundwater users at the TRA facility boundary. In addition, since releases from the ICDF landfill are negligible for the next 1,000 years, all the H-3 will decay away before any interaction with the ICDF landfill contaminants is possible.



Linear Regression Slope: -0.05
P-value: 0.021



Linear Regression Slope: -0.11
P-value: 0.064



Linear Regression Slope: -0.30
P-value: 6.5E-08

Figure 2-7. Tritium monitoring data with linear regression (black line) and pure decay (pink line) for selected wells near the RWMC (USGS-90 and M7S) and wells downgradient from INTEC (USGS-106).

The TRA (WAG 2) Comprehensive RI/FS indicates future (100 to 1,000 years) groundwater risks for the radionuclide COCs under the No Action Alternative are all well below the EPA target risk of 1E-06 or the contaminants' MCL, whichever is lower (Burns et al. 1997). The radionuclide inventory for TRA and predicted groundwater dose are shown in Table 2-1, which is adapted from Burns et al. 1997, Tables 4-4 and B-29. Estimated maximum groundwater doses at the TRA facility site boundary are all negligible. Therefore, TRA is excluded from the CA source term under the assumption that contaminants from TRA will not significantly contribute to the cumulative dose associated with the ICDF landfill source term.

Based on the TRA CERCLA results, radionuclide contamination from TRA is not expected to provide a significant aquifer dose at TRA and is therefore not expected to contribute significantly to the dose from the ICDF.

2.4.4.2 Naval Reactors Facility Contribution to the ICDF Landfill Cumulative Dose. The Final Record of Decision for NRF (DOE-ID 1998b) was issued September 1998. As documented in the ROD, NRF conducted controlled discharges of water contaminated with low levels of radionuclide contamination between 1953 and 1979. Approximately 1,500,000,000 L (417,000,000 gal) of water containing a total of 345.41 Ci were discharged to drainfields, pits, and beds at NRF between 1953 and 1979. The WAG 8 RI/FS groundwater assessment activities at NRF included GWSCREEN (Rood 1999) modeling and groundwater sampling. The NRF ROD concluded that the groundwater pathway is not a pathway of concern at NRF.

A cumulative risk assessment was performed for NRF to determine the overall impact of WAG 8 on future receptors. The cumulative risk assessment is intended to determine if there are additional risks due to the cumulative effects associated with having several individual areas near one another. The cumulative risk assessment evaluated the potential for future receptors to contact constituents present at more than one release site at WAG 8, and pertained to areas in which a source remained. The cumulative risk assessment considered the following exposure routes: inhalation, groundwater ingestion, and external exposure to radionuclides. Soil ingestion and crop ingestion were evaluated during the Track 2 assessments. The main COCs were determined by previous soil sampling investigations to be metals and radionuclides.

For the cumulative risk assessment, the radionuclides, which remained after screening for the groundwater ingestion pathway, were carbon-14, neptunium-237, plutonium-239, plutonium-234, uranium-234, and uranium-235. Weighted averages, based on the volume of the release site, and a scaling factor were used to develop a GWSCREEN model that represents the sum of all the combined volumes of soil. The thickness of the unsaturated zone was assumed to be 10.68 m (35 ft), corresponding to 6 m (20 ft) of alluvium and 4.5 m (15 ft) of interbeds which is representative of the approximate thickness of the sediments beneath WAG 8. Each contaminant was modeled using infiltration rates of 0.1 (10 times the average background infiltration) and 1.0 m/yr (3.3 ft/yr) (100 times the average background infiltration). The weighted-average concentration in groundwater was calculated for each COC by adjusting the length, width, and depth input parameters in proportion to the weighted average of the volume of each area affected by the respective constituent. A scaling factor was then used to adjust the new dimensions to match the sum of the combined volume of the soil containing the constituent.

The results of the cumulative risk assessment for groundwater ingestion using an infiltration rate of 0.1 m/yr are shown in Table 2-2. None of the radionuclide COCs are predicted to ever exceed the 1E-04 risk threshold from groundwater ingestion. C-14 is the only radionuclide predicted to reach groundwater within 1,000 years, but only under conditions of somewhat artificially high infiltration. With an infiltration rate of 0.1 m/yr (0.33 ft/yr), the peak concentration was predicted by GWSCREEN to occur

Table 2-1. TRA Comprehensive RI source term, predicted groundwater concentrations, and associated dose under the No Action Alternative.

COC	Activity in Surface Soil and Perched Water (both in Ci)	Predicted Groundwater Concentration (and all-pathways dose) from Surface Soil, Perched Water, and Injection Well Sources pCi/L (mrem/yr)		
		Year 30	Year 100	Year 1000
Ag-108m	5.51E-02	0.00E+00[a]	0.00E+00[a] (0)	0.00E+00[a] (0)
Am-241	5.75E+00 (2.95)	1.80E-06 (6E-6)	8.00E-06 (3E-5)	0.00E+00[a] (0)
Cm-244	5.02E-01	0.00E+00[b] (0)	0.00E+00[b] (0)	0.00E+00[b] (0)
Co-60	2.53E+00 (480)	5.00E-03 (2E-4)	1.50E-02 (6E-4)	0.00E+00[b] (0)
Cs-134	4.31E-01	0.00E+00[a] (0)	0.00E+00[a] (0)	0.00E+00[a] (0)
Cs-137	8.17E+01	0.00E+00[a] (0)	0.00E+00[a] (0)	0.00E+00[a] (0)
Eu-152	5.78E+00	0.00E+00[a] (0)	0.00E+00[a] (0)	0.00E+00[a] (0)
Eu-154	1.45E+00	0.00E+00[a] (0)	0.00E+00[a] (0)	0.00E+00[a] (0)
Eu-155	8.26E-02	0.00E+00[a] (0)	0.00E+00[a] (0)	0.00E+00[a] (0)
H-3	NA[c] (9,881)	2.20E+03 (0.3)	2.30E-01 (3E-5)	0.00E+00 (0)
Pu-238	5.74E-01	0.00E+00[b] (0)	0.00E+00[b] (0)	0.00E+00[b] (0)
Pu-239/240	6.10E+00	0.00E+00[b] (0)	0.00E+00[b] (0)	0.00E+00[b] (0)
Sr-90	1.24E+02 (111)	2.70E-01 (0.03)	3.00E-01 (0.035)	0.00E+00[b] (0)
Th-228	9.33E-03	0.00E+00[a] (0)	0.00E+00[a] (0)	0.00E+00[a] (0)
Th-230	2.23E-02	0.00E+00[a] (0)	0.00E+00[a] (0)	0.00E+00[a] (0)
Th-232	8.97E-03	0.00E+00[a] (0)	0.00E+00[a] (0)	0.00E+00[a] (0)
U-234	1.10E-01	0.00E+00[b] (0)	0.00E+00[b] (0)	0.00E+00[b] (0)
U-235	1.18E-03	0.00E+00[b] (0)	0.00E+00[b] (0)	0.00E+00[b] (0)
U-238	4.73E-02	0.00E+00[b] (0)	0.00E+00[b] (0)	0.00E+00[b] (0)

a. Contaminant is not expected to reach the aquifer before 1,000 years in the future due to retardation or radioactive decay.

b. Contaminant has a maximum estimated groundwater concentration that is less than 1E-10 pCi/L.

c. NA—not applicable.

Table 2-2. Predicted peak groundwater concentrations, corresponding risk, and all-pathways dose for NRF cumulative risk assessment with an infiltration rate of 0.1 m/yr.

Radionuclide	Peak Groundwater Concentration (pCi/L)	Time to Peak (yr)	Time to Reach Groundwater (yr)	Risk from Groundwater Ingestion Pathway	All-Pathways Dose (mrem/yr)
C-14	221	271	251	1E-06	1.30E+00
U-235	0.334	1,268	1,225	1E-07	6.51E-02
U-234	3.17	1,416	1,225	9E-07	6.41E-01
Np-237	0.649	5,274	4,472	1E-06	1.87E+00
Pu-244	0.0316	4,812	4,472	6E-08	—[a]
Pu-239	0.591	4,822	4,472	1E-06	1.87E+00

a. No known process release of Pu-244 at NRF.

at 271 years in the future and the maximum associated risk is 1E-06 (Table 2-2). The corresponding all-pathways dose is 1.3 mrem/yr for a receptor located at the point of assessment on the hypothetical waste volume boundary within NRF. Dose contribution to a receptor located downgradient of the ICDF landfill would be significantly smaller.

Uncertainties are acknowledged in the sampling data. Plutonium-244 was detected in two of 49 samples (4.1%) at very low activities near the detection limit. There was no known process release of Pu-244 at NRF; the presence of Pu-244 is therefore questionable. Uranium-235 was detected in only two of 78 samples (2.6 %) at very low activities near the detection limit. At one location, U-235 was detected in the duplicate sample but not the original sample, and U-235 is a naturally occurring radionuclide. Carbon-14 is a naturally occurring radionuclide. Any positive detection found during the Remedial Investigation was included in the risk assessment, and it is not established as to whether the values are representative of background. Americium-243 was detected in only one of 78 samples (1.3%) at a very low activity near the detection limit. There was no known process release of Am-243 at NRF, and the positive detection could be a statistical outlier.

Based on the NRF CERCLA results, radionuclide contamination from NRF is not expected to contribute significantly to the dose from the ICDF.

2.4.5 Excluded Sources Within the Downgradient Flow Corridor

Summarized below are the results of the RI/FS studies for remaining facilities (BORAX and CFA) in the downgradient groundwater flow corridor as defined in Section 2.2. If the CERCLA evaluation has not shown any significant risk to the aquifer, the respective facility is then assumed to not contribute to the dose from the ICDF. However, if the CERCLA evaluation does indicate a groundwater risk, then the predicted doses at BORAX and the CFA are calculated and evaluated as a possible dose contributors for the groundwater pathway.

2.4.5.1 BORAX Contribution to the ICDF Landfill Cumulative Dose. BORAX (WAG 6) includes the remains of the BORAX facilities. The BORAX-I reactor was a small experimental reactor used in the summer months during 1953 and 1954 for testing boiling water reactor technology. BORAX-I was designed to investigate the ability of the reactor to protect itself against sudden, artificially induced increases in reactivity. During the last test, the reactor was intentionally destroyed to determine its inherent safety under extreme conditions. An RI/FS (Holdren et al. 1995) was conducted for the BORAX-I facility and the results of this evaluation are explained below.

Subsequent BORAX experiments, BORAX-II through V, were conducted from 1954 to 1964 approximately 152 m (500 ft) east of BORAX-I. Potential release sites investigated at WAG 6 included old tanks, a small spill area, and several liquid and solid waste disposal locations. Decontamination and dismantlement operations have resulted in the complete removal of all structures in the BORAX (WAG 6) area with the exception of the remains of BORAX-I and the BORAX II-V basement, subbasement, and equipment (Rodman and Stoll 1994). Because very little waste remains in the BORAX-II through V area, it was defined as a "low probability hazard site" during the CERCLA process and no RI/FS was conducted for the site. Because there is no groundwater contamination expected from BORAX-II through V, it cannot be a cumulative dose driver at the ICDF landfill and is eliminated from further consideration.

The RI/FS for BORAX-I predicted no future groundwater risks greater than 10^{-6} (Holdren et al. 1995). GWSCREEN was used to assess the impacts to groundwater. The contaminated source volume was estimated as the volume of the BORAX installation. The longest pit/trench dimension was conservatively assumed to be parallel to the direction of regional groundwater flow, when the burial ground is actually oriented obliquely to the regional groundwater flow direction, and an infiltration rate of 0.1 m/yr was used. The receptor was located immediately downgradient on the edge of the facility. Actinides are the only radionuclides predicted to produce an appreciable all-pathways dose, which is on the order of 1.5 mrem/yr; but well beyond the 1,000-year compliance period (Table 2-3). A Record of Decision (LITCO 1996) was signed to contain the remains of the facility by capping with an engineered long-term barrier comprised primarily of natural materials to maintain effective long-term isolation of contaminants. BORAX-II through V was assessed under the CERCLA Track 1 process and a decision was made to contain the remains by placing a concrete cap over the site. This containment is expected to be protective of the groundwater.

Because the CERCLA evaluation indicates that the BORAX site will contribute no dose to the aquifer at the BORAX burial ground boundary until beyond 10,000 years and the predicted doses are very low, the BORAX facility is not considered a contributor to the cumulative dose at the ICDF landfill for the CA. BORAX is eliminated from further consideration as a potential downgradient cumulative dose contributor for the ICDF CA.

2.4.5.2 CFA Contribution to the ICDF Landfill Cumulative Dose. The radionuclide surface soil inventory for CFA and predicted groundwater concentrations and associated doses are shown in Table 2-4 (adapted from Burgess et al. 2000, Tables 6-9 through 6-11). Estimated maximum groundwater doses at the CFA boundary are all negligible. No radionuclide is predicted to produce greater than a 1-mrem/year dose at CFA during or beyond the 1,000-year compliance period. Dispersion and dilution

Table 2-3. Predicted peak groundwater concentration and dose at the BORAX burial ground boundary.

		Predicted Peak		
Nuclide	BORAX-I Inventory (Ci)	Groundwater Concentration (pCi/L)	Time (yr)	All-Pathways Dose (mrem/yr)
Cs-137	0.813	<1E-08	>10,000	<9.60E-10
Sm-151	0.0185	<1E-08	>10,000	ND[a]
Sr-90	0.763	<1E-08	4,500	<1.16E-09
U-234	0.25	7.6	>10,000	1.48E+00
U-235	0.00791	0.25	>10,000	4.68E-02
U-238	5.14E-05	0.0016	>10,000	2.87E-04

a. ND = not detected. All-pathways dose not calculated.

Table 2-4. CFA Comprehensive RI source term, predicted groundwater concentrations, and associated all-pathways dose under the No Action Alternative.

Radionuclide	Surface Soil Mass (Ci)	Groundwater Concentration[a] at 100–130 Years (pCi/L)	Peak Groundwater Concentration[a] (pCi/L)	Time of Peak Concentration (yr)	Peak All-Pathways Dose (mrem/yr)
Ac-228 (Th-228)[b]	7.84E-02 (2.87E-05)[b]	0.00E+00	0.00E+00 (0.00E+00)	N/A[c]	N/A[c]
Ag-108m	4.80E-05	0.00E+00	0.00E+00	N/A[c]	N/A[c]
Am-241 (Np-237)[b]	3.38E-02 (6.96E-06)[b]	0.00E+00	3.47E-05	2,640	1.00E-04
Ba-133	4.73E-06	0.00E+00	0.00E+00	N/A[c]	N/A[c]
Bi-212 (Pb-208)[b]	7.64E-02 (4.38E-24)[b]	0.00E+00	N/A[d]	N/A[d]	N/A[d]
Bi-214 (Pb-210)[b]	6.32E-02 (1.14E-07)[b]	0.00E+00	0.00E+00	N/A[c]	N/A[c]
Cs-137	7.63E+00	0.00E+00	0.00E+00	N/A[c]	N/A[c]
Eu-152	6.53E-05	0.00E+00	4.79E-03	41	2.66E-05
Pb-212 (Pb-208)[b]	8.03E-02 (4.85E-23)[b]	0.00E+00	N/A[d]	N/A[d]	N/A[d]
Pu-238 (U-234)[b]	7.12E-04 (2.55E-07)[b]	0.00E+00	2.56E-06	4,680	5.17E-07
Pu-239/240	1.44E-02	0.00E+00	1.06E-02	17,000	3.35E-02
Ra-226	2.95E-01	0.00E+00	8.49E-09	22,000	7.21E-09
Tl-208 (Pb-208)[b]	7.32E-02 (2.12E-25)[b]	0.00E+00	N/A[d]	N/A[d]	N/A[d]
U-234	1.17E-01	0.00E+00	3.54E+00	1,350	7.15E-01
U-235	5.93E-02	0.00E+00	2.56E-01	1,350	4.99E-02
U-238	1.30E-01	0.00E+00	3.91E+00	1,350	7.47E-01

a. Groundwater concentrations are the maximum predicted in a network of 10 receptor aquifer wells located in a line perpendicular to the flow direction immediately downgradient of the reference site (CFA-04).

b. Progeny.

c. Radionuclide decays to stable product before reaching receptor-well location.

d. Radionuclide with very short half-life (<1 yr) with no significant decay product was modeled as stable decay product. Bi-212, Pb-212, and Tl-208 soil inventories were converted to stable lead and were added to the total lead inventory.

are expected to significantly decrease the concentration and dose contribution from the ICDF landfill after transport to the area downgradient of the CFA. CFA is therefore excluded from the ICDF CA source term under the assumption that radionuclide contaminants from CFA will not contribute to the cumulative dose associated with the ICDF landfill source term.

2.5 Estimated Radionuclide Inventories and Release Rates

In this section, the estimated radionuclide inventories, release rates, and limitations are discussed. As explained in Section 2.1, only ICDF CA COCs inventories are discussed in this section. References are provided for the reader to research complete inventories estimated for the sources.

There are three types of release rates for the ICDF landfill CA sources. First, contaminants are placed directly into the aquifer from the disposal well at INTEC. Second, contaminants from the soil contamination sources (ICDF landfill and CERCLA soils) begin to travel through the vadose zone to the aquifer as soon as they are released to the soil. Third, contaminants from grouted sources (tanks in the tank farm, bin sets, WCF, NWCF, PEWE, CPP-601, and CPP-603) are released in 500 years and travel through the vadose zone to the aquifer.

In this CA, the assumption has been made that the grouted sources are stabilized for 500 years. During this time, there is no infiltration through the grout and, therefore, no leaching of contaminants to the vadose zone. It is assumed that after 500 years, the grout in the tanks and facilities would have the same hydrogeologic transport characteristics as the surrounding soil. However, chemical properties of the grout and concrete would remain unchanged. As discussed in the HLW&FD EIS (DOE 2002), studies have shown that cementitious materials (such as grout or concrete) can be expected to last for extended periods of time approaching 1,000 years or more (Poe 1998). Therefore, it is likely that the grout would retain its original hydraulic properties for much longer than the 500 years assumed in the analysis.

The grout stabilization for 500 years and the 1,000-year infiltration-reducing barrier on the ICDF landfill provide a separation in time between aquifer dose contribution from the ICDF, INTEC disposal well, CERCLA soil contamination sources, and the grouted tanks and facilities.

2.5.1 ICDF Landfill

The ICDF landfill design inventory report is discussed in detail in the ICDF PA (DOE-ID 2003a), which is a companion document to this report. The complete design inventory is presented in that document. The design inventory was based on the information provided in the CERCLA Waste Inventory Database Report (DOE-ID 2000b).

This ICDF landfill design inventory report identifies a preliminary waste inventory that will be used to assist in the design basis of the ICDF landfill. It is intended to provide a conservative estimate of the waste inventory that is expected to be disposed of in the landfill during the first 10 years of operation. To the extent analytical data were available on the contaminant concentration of the waste, those data were used to help determine the waste inventory. When analytical data were not available, contaminant concentrations for each release site were estimated based on process knowledge, releases from similar sites, scaling factors, or average contaminant concentrations from the waste. Since much of the design inventory is conservatively estimated, it should not be used to approximate actual site conditions. It does, however, provide an initial approximation of the wastes to be disposed of in the ICDF landfill and is appropriate for use in the current performance assessment and CA modeling.

The ICDF PA design inventory is shown in Table 2-5. The contaminants are assumed to be leached into the vadose zone by water infiltrating through the cover, into the waste, and then into the vadose zone. The cover is assumed to perform as designed for 500 years with net infiltration rate of 0.01 cm/yr (0.004 in./yr). The cover is assumed to degrade over the next 500 years with the net infiltration rate increasing linearly from the 0.01 cm/yr to 1 cm/yr (0.4 in./yr) (background, undisturbed soil infiltration rate). Details are provided in the ICDF PA (DOE-ID 2003a).

Table 2-5. ICDF PA design inventory for the ICDF landfill CA COCs.

CA COCs	ICDF PA Inventory (Ci)
Am-241	1.81E+01
C-14	3.50E-05
I-129	9.85E-01
Np-237	4.88E-01
Pu-239	5.06E+00
Pu-240	1.14E+00
Tc-99	4.37E+00
U-234	4.57E+00
U-238	1.48E+00

2.5.2 INTEC Tank Farm Facility Closure Action Residuals

The Tank Farm Facility (TFF) closure source term is based on a preliminary estimate of the bounding inventory for a given 300,000-gal tank based on the assumption that the worst-case measured concentration in any given tank, or that based on process knowledge, would be applied to each individual tank. The development of the bounding inventory is documented in the TFF closure performance assessment and CA (DOE-ID 2001a and DOE-ID 2002d). The bounding inventory is provided for the year 2018, which is the assumed year of completion of closure activities at the tank farm. The TFF closure residual source term inventory is shown in Table 2-6. The inventory is composed of three primary components: the residuals contamination left in the tanks after DD&D, the contaminants that have leaked to the sand pad, and the residual contamination remaining in the pipes.

The radionuclide contaminant inventory and source release functions chosen for this CA are based on the CA for the TFF closure (DOE-ID 2002d). Inventories are from Table 3-1 in DOE-ID (2002d) and the fluxes to the aquifer were obtained from the TFF closure modeling in DOE-ID (2001a). The following inventory (Table 2-6) has been taken from the TFF closure PA and CA reports. Fluxes from the TFF closure to the vadose zone were obtained from simulations by Portage Environmental, Inc. The fluxes were simulated for the CA TFF closure (DOE-ID 2002d). The fluxes from the tanks to the vadose zone assume that the tanks are left in place and filled with grout to stabilize the residual contamination. The grout is assumed to stabilize the residual contamination for 500 years. After 500 years, water will percolate through the grout, leaching the residual contamination to the vadose zone.

The conservative revised TFF closure PA inventory estimates are based on a conservative estimate of the residual contamination in the tanks. The conservative inventory estimates are up to an order of magnitude greater than the inventories used for the simulations presented in this report. However, one tank has been cleaned and preliminary inventory information indicates that inventory estimates are much greater than actual inventory found in the tank. Therefore, the TFF closure inventory is conservative. When better information is available based on estimates of cleaned tanks, the ICDF landfill CA simulations will be repeated using the new inventory and releases. The change in inventory is not expected to impact the ICDF CA conclusions. Table 2-7 is presented to show the inventory comparison.

Table 2-6. Tank Farm Facility closure residual inventory for year 2016.

	Tank Farm Facility Closure Inventory			
CA COCs	Sand Pad[a] (Ci)	Residual in Pipes[b] (Ci)	Tanks[c] (Ci)	Total (Ci)
Am-241	2.63E-01	1.37E-02	8.45E-01	1.12E+00
C-14	5.43E-08	3.43E-07	9.88E-01	9.88E-01
I-129	1.50E-07	1.50E-04	6.95E-03	7.10E-03
Np-237	5.17E-05	1.85E-04	1.00E-02	1.02E-02
Pu-239	2.19E-01	2.80E-02	1.70E+00	1.95E+00
Pu-240	4.92E-02	3.00E-02	1.39E+00	1.47E+00
Tc-99	2.81E-13	2.92E-01	1.13E+01	1.16E+01
U-234	4.35E-02	2.36E-03	1.09E-01	1.55E-01
U-238	1.25E-05	7.61E-06	4.35E-04	4.55E-04

a. From Table 2-15 in the Tank Farm Facility Closure PA report, DOE-ID (2001a).

b. From Table 2-17 in the Tank Farm Facility Closure PA report, DOE-ID (2001a).

c. From Table 3-1 in the Tank Farm Facility Closure CA report, DOE-ID (2002d).

Table 2-7. Comparison of the Tank Farm Facility closure residual inventory used for this ICDF landfill CA and the revised inventory currently under review.

	TFF Closure Inventory Used in this ICDF CA (Ci)	TFF Closure Inventory Currently Under Review (Ci)	Ratio of New Inventory to Old Inventory
Am-241	1.12E+00	1.08E+01	9.7
C-14	9.88E-01	5.63E+00	5.7
I-129	7.10E-03	2.97E-02	4.2
Np-237	1.02E-02	8.78E-02	8.6
Pu-239	1.95E+00	1.74E+01	8.9
Pu-240	1.47E+00	1.35E+01	9.2
Tc-99	1.16E+01	1.19E+01	1.0
U-234	1.55E-01	1.63E+00	10.5
U-238	4.55E-04	3.89E-03	8.6

The TFF inventory for C-14 is of particular interest because the TFF inventory estimates are as much as five orders of magnitude greater than expected based on the other source terms at INTEC, including the ICDF. The relatively high C-14 inventory for the TFF is because empirical data regarding the highest C-14 liquid analytical results from one of the tank farm storage tanks (WM-188) was used conservatively to create a worst-case, upperbound estimate for the inventory of what may be left in all of the tanks following closure. Subsequent to estimating the C-14 inventory for the TFF PA, it was determined that a low-energy beta emitter had interfered with the C-14 analytical results used to estimate the inventory. The corrected C-14 analytical results from WM-188 did not report detectable concentrations of C-14.

It should be noted that, even though C-14 and Tc-99 inventories were conservatively estimated for the TFF PA, results of the TFF PA indicate that the future aquifer concentrations will not present an unacceptable risk. For C-14, the TFF PA predicted a peak dose of 2.9E-11 mrem/yr. For Tc-99, the TFF PA predicted a peak dose of 0.87 mrem/yr. Adding the incremental predicted mass flux of C-14 and Tc-99 from ICDF to the very conservatively predicted tank farm plume does not result in an incremental increase in risk to a future receptor.

2.5.3 INTEC Bin Sets

The INTEC bin sets contaminant inventory has been estimated and used for both the Idaho HLW & FD EIS (computational information is in Tetra Tech NUS [2001]) and the Composite Analysis for Tank Farm Closure (DOE-ID 2002d). The same inventory was used for this CA.

The volume of the solids in the emptied bin set vessels is assumed to be 0.5% of the filled volume (Staiger 1998). The concentrations of radiological and chemical constituents in the emptied vessels are assumed to be the same as for the filled bin sets under the No Action Alternative, described above. These source term estimates employ the most conservative information on isotopic ratios and are conservatively based on liquid fed to the calciners and assume no recycle. The residual activity in the bin sets after closure (from Staiger and Millet 2000) were calculated at the years 2016, 2095, and 2516. In Table 2-8, the radionuclide activities are presented (from Table 4-10 in the HLW & FD EIS calculation package [Tetra Tech NUS 2001]) for the year 2016 inventory.

Table 2-8. Radionuclide inventory for the ICDF landfill CA COCs for the waste in the INTEC bin sets under the Performance-Based Closure/Closure to Landfill Standards Scenario for the year 2016.

CA COCs	Bin Sets Inventory (Ci)
Am-241	5.98E+01
C-14	1.90E-04
I-129	8.20E-03
Np-237	2.34E-00
Pu-239	2.41E+02
Pu-240	9.76E-00
Tc-99	2.28E+01
U-234	6.46E-01
U-238	1.56E-02

Results from simulations for the TFF closure performance assessment (DOE-ID 2001a) were used to define the bin sets release related radionuclide fluxes from the vadose zone to the aquifer. As explained in that report, degradation and releases of contaminants from the bin sets were assumed to be the same as those determined for the tanks at the TFF and presented in the performance assessment for TFF closure (DOE-ID 2001a). Therefore, the bin sets fluxes from the vadose zone to the aquifer were scaled from the fluxes calculated for the tank farm releases. The fluxes were incorporated into the simulations performed for this project.

2.5.4 INTEC Disposal Well

INTEC disposal well discharges were defined during the development of the contaminant transport model for the CERCLA WAG 3-13 Comprehensive RI/FS (DOE-ID 1997). The same disposal well fluxes are used for this ICDF CA. All of the disposal well flux was put directly into the aquifer model used for the ICDF CA. However, during the operating years of the disposal well, there were a number of failures during which times the well was blocked above the aquifer and the wastewater flowed into the vadose zone rather than directly to the aquifer. For purposes of this analysis, it was assumed that all the discharges to the disposal well went to the aquifer, because there are large uncertainties in vadose zone discharge estimates. The estimated discharges to the vadose zone are also included in the CERCLA vadose zone model, so the discharges are also included in the CERCLA contaminated soils section (Section 2.5.5). This is conservative because it double-counts the estimated discharge to the aquifer for this CA by including it in both the disposal well source and the CERCLA contaminated soils source. However, it is necessary to make the conservative assumption, because, for some contaminants, there are significant time separations for aquifer doses from sources discharged directly to the aquifer and sources discharged to the vadose zone. The conservative assumption is necessary; otherwise, it is possible that aquifer dose contributions that should be cumulative could be separated in time and underestimate the cumulative dose. This conservatism is not expected to have a significant impact on the predicted doses.

The total inventory (flux integrated from 1953 to 1986) estimated to be disposed of to the INTEC disposal well is shown in Table 2-9. The inventory was obtained from Appendix F of DOE-ID (1997).

Note that no C-14 or Tc-99 was reported in the inventory to the disposal well. There was an inventory of C-14, but it is not included in this analysis due to lack of source term data. The limitation of this assumption is discussed in Section 2.6. Note also that the Np-237 inventory is modified as discussed below.

Table 2-9. Inventory for the INTEC disposal well.

CA COCs	Total Inventory for the INTEC Disposal Well (Ci)
Am-241	1.23E-01
C-14	NS[a]
I-129	1.39E+00
Np-237	1.07E+00
Pu-239	1.35E-02
Pu-240	6.77E-03
Tc-99	NS[a]
U-234	1.35E-01
U-238	1.07E-01

a. NS—Not sampled and reported.

No C-14 or Tc-99 was reported as disposed of to the INTEC disposal well (Table 2-9). An inventory of C-14 and Tc-99 was present in the waste discharge but it is not included in this analysis due to lack of source term data. The INTEC disposal well is a significant contributor to the inventory; however, the time frame (the last 50 years) of the releases are offset in time from the ICDF landfill releases by 500 to 1,000 years because there are no significant releases from the ICDF for at least the next 500 years. Although the Comprehensive RI/BRA for the INTEC did not estimate a disposal well source term for C-14 and Tc-99, aquifer-monitoring downgradient of the INTEC has been ongoing. Analysis for Tc-99 has been a part of the regular monitoring and analysis of C-14 has been added to the regular monitoring in response to the needs of the ICDF PA and CA. This monitoring is the best evidence for evaluation of the disposal well contribution to aquifer dose. Although relatively low concentrations of C-14 and Tc-99 have been detected in the aquifer, the concentrations have always been significantly below the MCL and dose limits.

Based on 2001 monitoring data (DOE-ID 2002e) of 53 aquifer wells at INTEC and downgradient, the maximum Tc-99 concentration was 322 pCi/L, two wells had concentrations close to 100 pCi/L, and the remaining wells were all below 40 pCi/L (Figure 2-8 and Table 2-10). The Tc-99 MCL is 900 pCi/L. For the next 100 years, the point of compliance is at the INEEL boundary, not in the vicinity of the INTEC. Far downgradient of the INTEC, the Tc-99 concentrations are very low. Therefore, there is no indication of a Tc-99 source to the aquifer that is a significant contributor to dose at the receptor location. Recent sampling included analysis for C-14. Although the results have not been verified or published as yet, preliminary indications are that the C-14 concentrations at all the aquifer wells were at least two orders of magnitude below the MCL of 2000 pCi/L. Therefore, the C-14 and Tc-99 inventories to the disposal well are not significant contributors to the CA dose. Continued aquifer monitoring for C-14 and Tc-99 will be reported in the annual report.

The Np-237 reported as disposed of to the INTEC disposal well (DOE-ID 1997) was based on two reported detections in the wastewater between 1952 and 1984. In order to be conservative, these samples were assumed to be representative of the entire 32-year period. This source term was used in the ICDF CA predictions. In the ICDF CA, the predicted peak aquifer concentration at Receptor 2 is predicted to occur in year 2600 at a concentration of 29 pCi/L. However, extensive sampling of the aquifer over the last 5 years indicates that there is very little Np-237 in the aquifer. Results from the latest sampling event (DOE-ID 2002e) analyzed for Np-237 in 44 wells in the vicinity and downgradient of INTEC and had no positive Np-237 detections. The detection limit was approximately 0.1 pCi/L. Based on the sampling

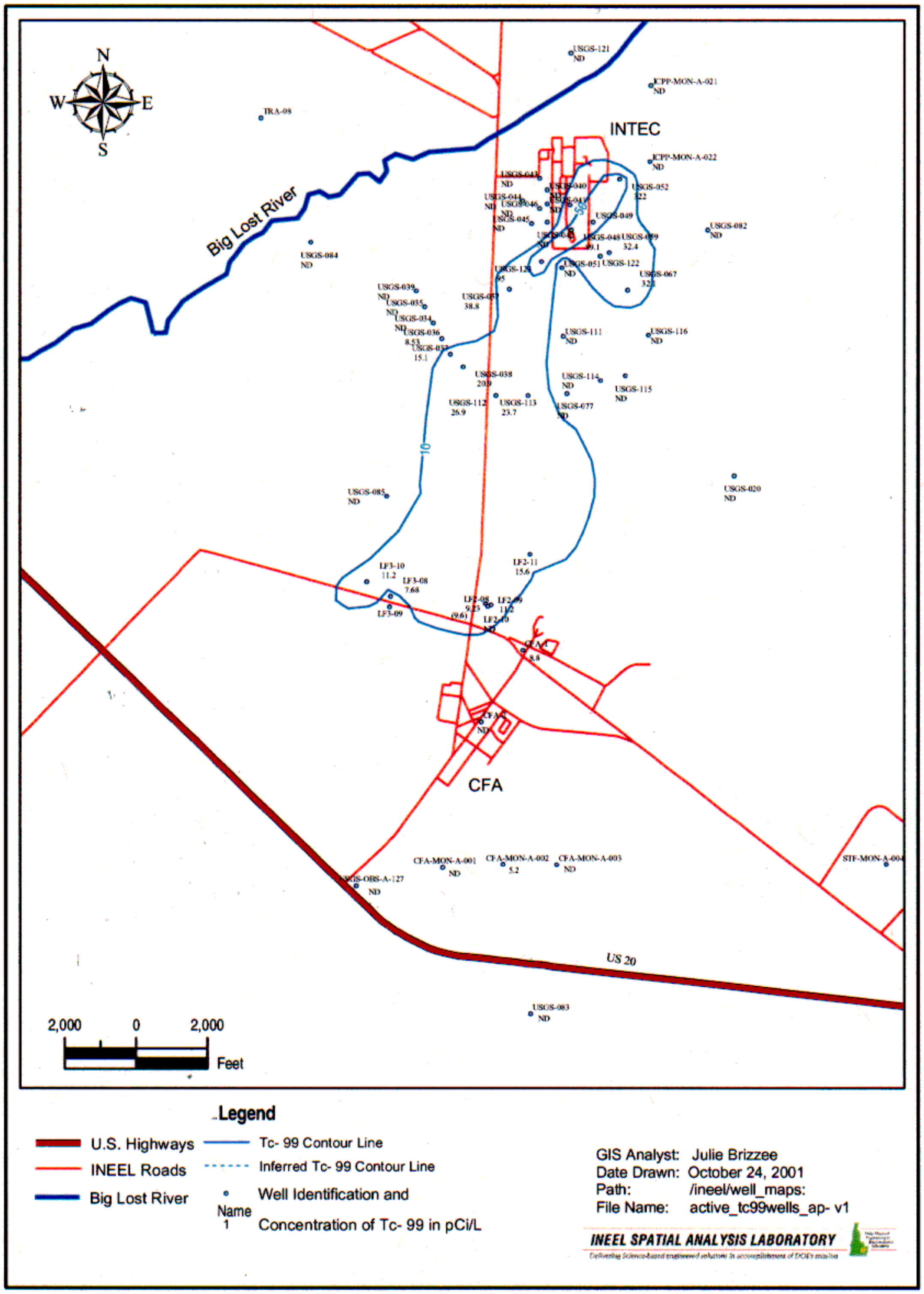


Figure 2-8. Distribution of Tc-99 in the SRPA in 2001.

Table 2-10. Summary of Tc-99 concentrations in the SRPA in the vicinity and downgradient of INTEC (MCL for Tc-99 is 900 pCi/L).

Well	Tc-99 (pCi/L)[a]	Standard Deviation +/- (pCi/L)	Well	Tc-99 (pCi/L)[a]	Standard Deviation +/- (pCi/L)
ICPP-MON-A021	-2.38	1.53	USGS-42	1.36	1.53
ICPP-MON-A022	2.75	2.92	USGS-43	-1.77	1.47
CFA-1	8.8	4.9	USGS-44	-2.8	1.45
CFA-2	0.8	4.4	USGS-45	8.29	2.3
CFA-MON-A-001	0.1	4.1	USGS-46	3	2.38
CFA-MON-A-002	5.28	2.8	USGS-47	38.3	2.78
CFA-MON-A-003	2.5	3.0	USGS-48	89.1	2.79
CFA-1606	3.9	3.0	USGS-51	4.28	2.37
CFA-1606	5.6	3.1	USGS-52	322	6.6
LF 2-10	0.897	1.51	USGS-57	38.8	2.03
LF 2-11	15.6	1.92	USGS-59	32.4	1.91
LF 2-8[b]	9.6	4.6	USGS-67	32.1	2.64
LF 2-8	9.23	1.68	USGS-77	5.48	2.47
LF 2-9	11.2	1.75	USGS-82	-2.3	1.65
LF 3-10	11.2	1.86	USGS-83	3.3	2.8
LF 3-8	7.68	1.71	USGS-84	-6.7	2.66
LF 3-8	8.38	1.86	USGS-85	2.35	2.27
USGS-20	1.14	1.52	USGS-111	0.833	1.52
USGS-34	4.89	2.25	USGS-112	26.9	2.61
USGS-35	0.799	2.37	USGS-113	23.7	1.81
USGS-36	8.53	2.6	USGS-114	4.46	1.57
USGS-37	14	1.7	USGS-115	2.6	2.28
USGS-37	15.1	1.72	USGS-116	5.51	2.28
USGS-38	20.9	1.93	USGS-121	-0.439	1.54
USGS-39	0.0773	2.51	USGS-123	95	2.83
USGS-40	-2.33	1.47	USGS-127	2.2	3.2
USGS-41	-0.419	1.47	RINSE	-3.94	1.54

a. Negative result values occur when the established background for a detector is greater than the count result sample (background is subtracted from the count result).

b. Resampled in August 2001.

results, the Np-237 inventory estimated for the injection well is at least 300 times larger than the inventory actually disposed of to the aquifer.

In order to verify that the Np-237 inventory assumed for the disposal well was overestimated, an evaluation of the ratios of Np-237 to Pu-238, Pu-239, and Sr-90 inventories for different sources at INTEC (Table 2-11) was made. Results of that comparison indicate that the Np-237 inventory assumed for the INTEC disposal well is overestimated by a factor of between 122 and 2,000,000 based on its ratio to Pu-238, Pu-239, and Sr-90.

In order to make the disposal well inventory and the predicted Np-237 aquifer concentrations consistent with process knowledge and recent sampling data, the disposal well inventory has been reduced by a factor of 100 for the final ICDF CA simulations. The adjusted inventory is still conservative and consistent with the aquifer sampling results and the other INTEC source inventories.

The estimated discharges to the vadose zone from the INTEC disposal well are included in CERCLA vadose zone model, so the discharges are also included in the CERCLA contaminated soils section of the CA. This is conservative because it double-counts a portion of the estimated discharge to the aquifer for the CA by including it in both the disposal well source and the CERCLA contaminated soils source. The disposal well portion of the discharge to the vadose zone rather than the aquifer is unknown. It is necessary to make the conservative assumption because for some contaminants there are significant time separations for aquifer doses from sources directly to the aquifer and sources to the vadose zone. This conservatism is not expected to have a significant impact on the predicted doses.

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Table 2-11. Comparison of the ratios of Np-237 to Pu-238, Pu-239, and Sr-90.

	Np-237 Inventory (Ci)	Pu-238 Inventory (Ci)	Ratio of Np-237 to Pu-238	Pu-239 Inventory (Ci)	Ratio of Np-237 to Pu-239	Sr-90 Inventory (Ci)	Ratio of Np-237 to Sr-90
Disposal well[a]	1.07E+00	4.38E-01	2.4	2.03E-01	5.27	2.43E+01	0.044
ORIGEN II runs[a]	3.70E-07	1.10E-04	3.36E-03	6.40E-05	5.78E-03	2.30E-01	1.61E-06
RI/BRA CPP-28[a]	1.33E-04	No data	No data	1.02E+00	1.30E-04	6.15E+03	2.17E-08
RI/BRA CPP-31[a]	2.16E-01	No data	No data	8.46E+00	2.55E-02	1.18E+04	1.83E-05
TFF closure[b]	1.02E-02	1.10E+02	9.30E-05	1.95E+00	5.23E-03	9.52E+03	1.07E-06

a. These source inventories are from Appendix F of the INTEC Comprehensive RI/BRA (DOE-ID 1997).

b. The TFF closure inventory is from the PA for the TFF closure (DOE-ID 2001a).

2.5.5 INTEC CERCLA Contaminated Soils Sites

For the CERCLA WAG 3-13 Comprehensive RI/FS (DOE-ID 1997), two subsurface flow and transport models were developed, a vadose zone model and an aquifer model. These models are referred to as the CERCLA models. The mass or activity flux from the CERCLA vadose zone model was used as an input to the CERCLA aquifer model. For this ICDF CA modeling, the contaminant fluxes from the CERCLA vadose zone model were incorporated into the ICDF CA aquifer modeling. Details on the CERCLA modeling can be found in Appendix F of DOE-ID (1997).

As discussed in Section 2.3.5, the CERCLA contaminated soils include contaminated soils from all over the INTEC facility. In addition, there are fluxes from the service waste ponds and fluxes from periods when the INTEC disposal well failed and discharged to the vadose zone. However, the primary concentration of contaminated soils is in the vicinity of the tank farm. For this ICDF CA modeling, it is assumed that all the contaminated soils are centered at the tank farm.

Shown in Table 2-12 are inventories associated with the INTEC CERCLA soils sites. For the CA modeling presented in this report, the INTEC CERCLA soils contamination is input to the CA aquifer model as fluxes obtained from the INTEC comprehensive RI/BRA (DOE-ID 1997) vadose zone modeling and some minor extrapolation in time. The columns in the table are

1. List of the contaminants of concern addressed for this CA.
2. The inventory associated with surface soils contamination at INTEC. For this report, these are referred to as the INTEC CERCLA contaminated soils. These values are taken from Sections 5 and 6 of Appendix F in the CERCLA WAG 3-13 Comprehensive RI/FS (DOE-ID 1997).
3. Simulation time used in the CERCLA model for each of the COCs.
4. Integrated activity released from the CERCLA vadose zone model over the time frame of the CERCLA models.
5. Simulation time used to define the flux of each COC to the model developed for this CA.
6. Integrated activity released from the CERCLA vadose zone model extended to the time frame used to define the flux to the aquifer for the model developed for this CA.
7. Relevant comments for each of the COCs.

Table 2-12 shows the following:

- An estimated 111 Ci of Am-241 were assumed to exist in the surface sediments at INTEC (Column 2). The CERCLA vadose zone model was simulated for 1,500 years and, during that time, 2.88E-05 Ci (Column 4) of Am-241 were leached from the vadose zone to the aquifer. For this CA modeling, the Am-241 flux is assumed to occur over 3000 years and the total flux is estimated to be 5.26E-05 Ci over this time period (Column 6). Note that the radioactive decay half-life of Am-241 is 432 years so that 3,000 years is about seven half-lives. Of the 111 Ci initially present, less than 1 Ci will remain in 3,000 years. As can be seen in the table, the vast majority of the remaining activity is still in the vadose zone after 3,000 years. In other words, essentially all the Am-241 will decay away in the vadose zone because americium is strongly sorbed and the Am-241 radioactive decay half-life is sufficiently short that very little of the Am-241 is predicted to ever reach the aquifer.

Table 2-12. For the ICDF landfill CA COCs total flux from the INTEC CERCLA contaminated soils sites, plus support information.

		Total Flux from the WAG 3-13 Vadose Zone Model to the Aquifer				
		WAG 3-13 Aquifer Model[a]		ICDF CA Model		
CA COCs	Surface Soils Inventory—INTEC CERCLA Soils (Ci)	Flux Timeframe (yr)	Cumulative Flux to Aquifer (Ci)	Flux Timeframe (yr)	Cumulative Flux to Aquifer (Ci)	Comments
Am-241	1.11E+02	1500	2.88E-05	3000	5.26E-05	Decays away in vadose zone
C-14	NS[b]	—	—	—	—	Not sampled or reported
I-129	1.30E-01	137	2.80E-01	400	2.81E-01	Significant flux from the backed up disposal well
Np-237	3.50E-01	838	2.75E-01	1700	3.88E-01	Some flux from the backed up disposal well
Pu-239	1.04E+01	84,500	6.54E+00	84,500	6.54E+00	Some decay in the vadose zone
Pu-240	6.84E+00	84,500	9.89E-01	84,500	9.89E-01	Significant decay in the vadose zone
Tc-99	2.69E+00	224.6	2.69E+00	600	2.69E+00	Same as total—disposal well estimate is zero
U-234	9.59E-01	986	7.01E-01	2000	9.79E-01	Slight contribution from disposal well
U-238	8.71E-01	986	6.38E-01	2000	8.91E-01	Slight contribution from disposal well

a. From the OU 3-13 modeling (DOE-ID 1997).

b. NS—Not sampled or reported.

- There are no C-14 inventories reported in the INTEC CERCLA soils inventory. Therefore, C-14 was not considered as a source in the INTEC comprehensive RI/BRA modeling. The influence of neglecting C-14 as a source is discussed in Section 2.6 together with other limitations of the inventory.

- An estimated 0.13 Ci of I-129 were assumed to exist in the surface sediments at the INTEC (Column 2). The CERCLA vadose zone model was simulated for 137 years and, during that time, 0.28 Ci (Column 4) of I-129 were estimated to be leached from the vadose zone to the aquifer. The reason that the I-129 flux from the vadose zone is greater than the I-129 in the surface sediments is that failure of the disposal well over the years was simulated as a flux into the vadose zone. Therefore, the majority of the I-129 flux is actually disposal well flux. However, it is impossible to quantify the portion of the disposal well flux that goes into the aquifer versus that into the vadose zone. Therefore, the relatively small portion of the disposal well flux discharged to the vadose zone rather than the aquifer is double-counted for in this CA. In other words, it is input both directly to the aquifer as part of the disposal well flux and input to the vadose zone as part of the flux to the vadose zone. Since the fluxes directly to the aquifer and the fluxes to the vadose zone contribute to the predicted dose during different time periods, it is important to simulate both and evaluate their potential to contribute to the cumulative dose. For this CA modeling, the I-129 flux is assumed to occur over 400 years and the total flux is estimated to be 0.281 Ci (Column 6).

- An estimated 0.35 Ci of Np-237 were assumed to exist in the surface sediments at the INTEC (Column 2). The CERCLA vadose zone model were simulated for 838 years and, during that time, 0.275 Ci (Column 4) of Np-237 were estimated to be leached from the vadose zone to the aquifer. For this CA modeling, the Np-237 flux is assumed to occur over 1,700 years and the total flux is estimated to be 0.388 Ci (Column 6). There is a small contribution of Np-237 from the disposal well failure.

- An estimated 10.4 Ci of Pu-239 were assumed to exist in the surface sediments at the INTEC (Column 2). The CERCLA vadose zone model was simulated for 84,500 years and, during that time, 6.54 Ci (Column 4) of Pu-239 were estimated to be leached from the vadose zone to the aquifer. Of the 6.54 Ci leached to the aquifer, half was released in the first 20,000 years and over 90% was released in the first 35,000 years. Pu-239 has a 24,100-year radioactive decay half-life. Therefore, a significant portion of the Pu-239 has decayed in 35,000 years. For this CA modeling, the Pu-239 flux is assumed to occur over 84,500 years and the total flux is estimated to be 6.54 Ci (Column 6). After 84,500 years, almost all of the Pu-239 is assumed to have been leached from the vadose zone to the aquifer or to have decayed away.

- An estimated 6.84 Ci of Pu-240 were assumed to exist in the surface sediments at the INTEC (Column 2). The CERCLA vadose zone model were simulated for 84,500 years and, during that time, 0.99 Ci (Column 4) of Pu-240 were estimated to leach from the vadose zone to the aquifer. For this CA modeling, the Pu-240 flux is assumed to occur over 84,500 years and the total flux is estimated to be 0.99 Ci (Column 6). A significant portion of the Pu-240 is assumed to have decayed in the vadose zone (radioactive decay half-life of 6,560 years) before it could be leached from the vadose zone to the aquifer.

- An estimated 2.69 Ci of Tc-99 were assumed to exist in the surface sediments at the INTEC (Column 2). The CERCLA vadose zone model was simulated for 225 years and, during that time, all 2.69 Ci (Column 4) of Tc-99 were estimated to leach from the vadose zone to the aquifer. For this CA modeling, the Tc-99 flux is assumed to occur over 600 years and the total flux is estimated to be 2.69 Ci (Column 6). Virtually all of the Tc-99 was leached from the vadose zone in the first 225 years, so the flux for the remaining 375 years was assumed to be very low. Note that there was no Tc-99 flux estimated for the disposal well source. Therefore, the flux from the vadose zone is exactly the same as the surface soils inventory.

- An estimated 0.96 Ci of U-234 were assumed to exist in the surface sediments at the INTEC (Column 2). The CERCLA vadose zone model was simulated for 986 years and, during that time, 0.70 Ci (Column 4) of U-234 were estimated to leach from the vadose zone to the aquifer. For this CA modeling, the U-234 flux is assumed to occur over 2,000 years and the total flux is estimated to be 0.98 Ci (Column 6). There is a small contribution of U-234 from the disposal well failure.

- An estimated 0.87 Ci of U-238 were assumed to exist in the surface sediments at the INTEC (Column 2). The CERCLA vadose zone model was simulated for 986 years and, during that time, 0.64 Ci (Column 4) of U-238 were estimated to leach from the vadose zone to the aquifer. For this CA modeling, the U-238 flux is assumed to occur over 2,000 years and the total flux is estimated to be 0.89 Ci (Column 6). There is a small contribution of U-238 from the disposal well failure.

The CERCLA soils release to the vadose zone includes leaching from the surface soils, direct placement of contaminants into the basalts below the surface sediments (known releases from Sites CPP-28 and CPP-31 at the tank farm), and direct placement of contaminants in the deep vadose zone from the disposal well during periods when the disposal well was blocked. Placement of the CPP-28 and CPP-31 releases into the basalt below the sediments is conservative. In reality, transport of some of the nuclides was retarded in surface sediments before being leached to the vadose zone basalts.

Much of the CERCLA soil will be excavated and moved to the ICDF landfill. However, since the majority of the activity is in the tank farm soils and will not be moved, the contaminated soils are assumed to be all left in place and double-counted. This is a conservative assumption that is evaluated later in the report.

The primary contributors to the INTEC CERCLA soils source term are releases for Sites CPP-28 and CPP-31 in the tank farm soils. The inventories for these releases were estimated during the WAG 3 Comprehensive RI/BRA evaluation (DOE-ID 1997). These were the inventories used for this ICDF CA evaluation. However, there has been a reevaluation of the inventories since 1997 (Jenkins 2000). It is worthwhile to compare these inventories because Sites CPP-28 and CPP-31 are the primary contributors for many of the nuclides in the CERCLA soils. The inventories for these releases were estimated during the WAG 3 Comprehensive RI/BRA evaluation (DOE-ID 1997). Of the CERCLA soils, Sites CPP-28 and CPP-31 account for over 90% of the Am-241, Pu-239, Pu-240, and Tc-99. They account for over 62% of the Np-237 and the U-234. But they account for only 5% of the I-129 and 0.2% of the U-238. Therefore, CPP-28 and CPP-31 are very significant contributors to the overall inventory for the ICDF CA.

The newer inventories have not been used in an evaluation of the transport of contaminants from the tank farm soils to the aquifer; therefore, the more recent estimates were not used in this evaluation. However, it is important to note that the more recent estimates are significantly lower than the estimates used in this CA evaluation. Table 2-13 compares the inventories used for this ICDF CA evaluation and the more recent evaluation.

The inventory used the CERCLA evaluation as well as this ICDF CA evaluation is larger than the newer estimates by a factor of 1.29 up to 17.38. However, no C-14 was estimated for either the CERCLA CPP-28 or CPP-31 estimates. In addition, no Am-241 or I-129 was estimated for the CERCLA CPP-28 inventory. Impacts on the ICDF CA are discussed in Section 2.6.

Table 2-13. Comparison of the CPP-28 and CPP-31 inventories used in this report with the estimates presented in DOE-ID (2000b).

CA-COC	CPP-31		CPP-28		CPP-31 Plus CPP-28 Total		Ratio of Totals
	CERCLA[a] (Ci)	Revised[b] (Ci)	CERCLA[a] (Ci)	Revised[c] (Ci)	CERCLA (Ci)	Revised (Ci)	Ratio of Total CERCLA to Revised Inventory
Am-241	1.10E+02	4.27E+00	NS[d]	2.03E+00	1.10E+02	6.30E+00	17.38
C-14	NS[d]	3.91E-06	NS[d]	1.17E-05	NS[d]	1.56E-05	—
I-129	7.04E-03	1.30E-03	NS[d]	1.93E-04	7.04E-03	1.49E-03	4.72
Np-237	2.16E-01	3.60E-02	1.33E-04	4.38E-03	2.16E-01	4.04E-02	5.34
Pu-239	8.46E+00	2.66E+00	1.02E+00	6.03E-01	9.48E+00	3.26E+00	2.90
Pu-240	5.46E+00	9.74E-01	1.01E+00	3.66E-01	6.47E+00	1.34E+00	4.83
Tc-99	2.58E+00	5.23E-01	NS[d]	1.47E+00	2.58E+00	1.99E+00	1.29
U-234	6.69E-01	4.97E-02	3.61E-02	5.51E-03	7.05E-01	5.52E-02	12.77
U-238	1.84E-03	2.20E-04	3.54E-05	1.04E-04	1.87E-03	3.24E-04	5.78

a. From Sections 5 and 6 of DOE-ID (1997).

b. From Table 2 in Jenkins (2000).

c. From Table 9 in Jenkins (2000). This is the inventory titled the "Individual Waste Campaigns Decayed Inventory."

d. NS—Not sampled or reported.

2.5.6 WCF, NWCF, and PEWE

Three of the INTEC HLW facilities evaluated for this CA are the Waste Calcining Facility (known as the WCF or CPP-633), the New Waste Calcining Facility (known as the NWCF or CPP-659), and the Process Equipment Waste Evaporator (known as the PEWE or CPP-604). DOE previously estimated (Beck 1998) that the residual inventory in the NWCF and PEWE after closure would be less than the amount remaining in the WCF after it was closed (DOE 2002). Therefore, for the HLW EIS analysis, TFF closure analysis, as well as this ICDF CA analysis, it is conservatively assumed that the residual inventory in the NWCF and the PEWE would be equal to that in the residual inventory in the WCF. The characteristics of the residual remaining in the WCF are described by Demmer and Archibald (1995). Presented in Table 2-14 are the residual activities after closure in the WCF, NWCF, and PEWE. The information presented in Table 2-14 is from Table 4-13 in the calculation package of the HLW-EIS (Tetra Tech NUS 2001).

The residual activity in the WCF is contained in the grouted facility. It is also assumed that the residual activity in the NWCF and PEWE will be grouted. For purposes of this CA, it is assumed that the grouted facilities will remain intact for 500 years and, afterwards, the residual activity will be leached from the grout using grout-to-water partition coefficients. After leaving the grout, the residual activity will be transported through the vadose zone. The transport rate through the vadose zone is estimated using the same soil-to-water partition coefficients used for the ICDF PA.

Note that no C-14 or I-129 was reported in the WCF residual inventory. There is C-14 and I-129 in the residual but it is not included in this analysis due to lack of source term data. The limitations of this assumption are discussed in Section 2.6. However, as shown in Tables 2-17 and 2-18 in Section 2.6, the nuclide contribution from WCF, NWCF, and the PEWE are very low. Therefore, it is reasonable to expect that the inventory of C-14 and I-129 would be negligible contributors to the CA dose. Despite the apparent negligible inventory of C-14 and I-129 at these sources, future sampling will include these radionuclides because they are identified as possible COCs in the ICDF PA and this CA.

Table 2-14. Radionuclide waste constituents for the INTEC WCF, NWCF, and PEWE under the Performance-Based Closure/Closure to Landfill Standards Scenario.

CA COCs	WCF Inventory (Ci)	NWCF Inventory[a] (Ci)	PEWE Inventory[a] (Ci)
Am-241	7.20E-01	7.20E-01	7.20E-01
C-14	NS[b]	NS[b]	NS[b]
I-129	NS[b]	NS[b]	NS[b]
Np-237	7.00E-03	7.00E-03	7.00E-03
Pu-239	1.30E-01	1.30E-01	1.30E-01
Pu-240	8.00E-02	8.00E-02	8.00E-02
Tc-99	3.50E-01	3.50E-01	3.50E-01
U-234	6.00E-03	6.00E-03	6.00E-03
U-238	2.42E-05	2.42E-05	2.42E-05

a. Assumed to be the same as the WCF inventory.

b. NS—Not sampled and reported.

2.5.7 Fuel Processing Complex, CPP-601

The assumed inventory for CPP-601 is shown in Table 2-15, as taken from Table 4 in the preliminary draft INTEC environmental assessment.[d] It will be some time before the facility is closed down and decontaminated. However, it is currently assumed that the residual contamination will be grouted in place. Therefore, it is assumed that the residual contamination will be tied up for approximately 500 years and then leached from the grout to the vadose zone for transport to the aquifer.

Table 2-15. CPP-601 radionuclide inventory.

CA COCs	CPP-601 Inventory (Ci)
Am-241	2.79E+00
C-14	2.92E-07
I-129	1.83E-02
Np-237	1.70E-03
Pu-239	3.00E-02
Pu-240	1.47E-02
Tc-99	6.36E-02
U-234	7.82E-04
U-238	1.11E-05

2.5.8 Fuel Receipt and Storage Facility, CPP-603

Building CPP-603 in the southern part of INTEC will be closed down over the next few years. In order to choose an appropriate option for final closure, it is necessary to evaluate the potential risks to groundwater quality after closure. In support of the CPP-603 Environmental Evaluation, an Engineering Design File was written that documents the approach taken to predict future groundwater concentrations from leaching of residual contamination (EDF-1962). The preferred closure option involves removing as much of the sludge in the CPP-603 basins as possible and then grouting the basins over a period of 8 years. This closure option is assumed to remove 90% of the contamination in the basins. In addition, it is assumed Tank SFE-106 will be clean-closed under HWMA/RCRA. For this CA, it is assumed the preferred option will be implemented. The estimated CPP-603 basins' initial inventory and inventory after removal of the sludge are shown in Table 2-16, based on Table 3-2 in EDF-1962.

The CPP-603 fuel basin area is composed of three storage basins and a transfer canal. For this analysis, a single equivalent source rectangle was defined in order to calculate the potential for contamination of the aquifer. The source was assumed to have the same area as the total area of the storage basins and transfer canal (~918 m^2). Because no spreading (one-dimensional flow) is assumed in the vadose zone, this is a conservative assumption. The source length is assumed to be twice the width in order to reproduce the general shape of the basins. The equivalent source length (source dimension parallel to the direction of groundwater flow) and width are assumed to be 42.9 m (140 ft) and 21.4 m (70 ft), respectively. The primary source-term-related assumption of the analysis is the assumed intact life

d. Personal communication between J.M. McCarthy, BBWI, and J. S. Irving, BBWI, August 21, 2003, regarding unpublished document, "Preliminary Draft—Environmental Assessment and Deactivation Plan for Obsolete Spent Nuclear Fuel Processing, Storage, and Support Facilities at the Idaho Nuclear Technology and Engineering Center (INTEC)," DOE-EA-1244, U.S. Department of Energy Idaho Operations Office, September 1998.

Table 2-16. Estimated CPP-603 basins initial inventory of radionuclides and inventory remaining after sludge removal.

CA COCs	CPP-603 Inventory (Ci)
Am-241	4.2E-03
C-14	NS[a]
I-129	NS[a]
Np-237	5.0E-04
Pu-239	2.2E-01
Pu-240	NS[a]
Tc-99	NS[a]
U-234	3.0E-02
U-238	1.7E-04

a. NS—Not sampled and reported.

span of the grouted CPP-603 ponds. The assumed intact life span of the grouted CPP-603 basins after final disposition is 500 years (EDF-1962). This is based on similar assumptions in the HLW&FD EIS (DOE 2000). Complete failure is assumed at the end of the intact life span. Water was assumed to infiltrate at 0.04 m/yr (1.6 in./yr) through the grouted waste material and begin the process of transporting contaminants from the source term area to the vadose zone.

Note that there is no inventory of C-14, I-129, Pu-240, or Tc-99 reported for the CPP-603 residual. Each of these nuclides will be included in the residual but they were not included in this analysis due to lack of source term data. Limitations of this assumption are discussed in Section 2.6. As can be seen from Tables 2-17 and 2-18 in Section 2.6, reported inventory from CPP-603 sites is negligible and the C-14, I-129, Pu-240, and Tc-99 inventories would be negligible as well.

2.6 Discussion of the ICDF CA Inventories and Source Terms

Presented in Tables 2-17 and 2-18 are comparisons of the assumed inventories from each of the ICDF landfill CA sources and the fractional inventory contribution from each source. The fractional contribution is calculated both including and excluding (shown in parenthesis) the ICDF landfill inventory. As shown in the tables, the fractional inventory contribution from the WCF, NWCF, PEWE, CPP-601, and CPP-603 are negligible compared to the other sources. Of the remaining sources, each is a significant contributor to the inventory for at least two of the ICDF landfill CA COCs.

2.6.1 Inventory Uncertainties

The inventory used for this ICDF CA analysis is based on past analyses. In some cases, the inventory has been overestimated and in others underestimated. This section summarizes the uncertainties in the inventories.

Much of the CERCLA soil will be excavated and moved to the ICDF landfill. However, since a significant portion of the activity is in the tank farm soils and will not be moved, the contaminated soils are assumed to be all left in place and double-counted. This is a conservative assumption.

Table 2-17. Comparison of the inventory for all of the ICDF CA sources.

CA COCs	ICDF Landfill (Ci)	TFF Closure (Ci)	Bin Sets (Ci)	INTEC Disposal Well (Ci)	INTEC CERCLA Contaminated Soil Sites[a] (Ci)	WCF (Ci)	NWCF (Ci)	PEWE (Ci)	CPP-601 (Ci)	CPP-603 (Ci)	Total Inventory (Ci)
Am-241	1.81E+01	1.12E+00	5.98E+01	1.23E-01	1.11E+02	7.20E-01	7.20E-01	7.20E-01	2.79E+00	4.20E-03	1.95E+02
C-14	3.50E-05	9.88E-01	1.90E-04	NS[b]	NS[b]	NS[b]	NS[b]	NS[b]	2.92E-07	NS[b]	9.88E-01
I-129	9.85E-01	7.10E-03	8.20E-03	1.39E+00	1.30E-01	NS[b]	NS[b]	NS[b]	1.83E-02	NS[b]	2.54E+00
Np-237	4.88E-01	1.02E-02	2.34E+00	1.07E-02[c]	3.50E-01	7.00E-03	7.00E-03	7.00E-03	1.70E-03	5.00E-04	3.22E+00
Pu-239	5.06E+00	1.95E+00	2.41E+02	1.35E-02	1.04E+01	1.30E-01	1.30E-01	1.30E-01	3.00E-02	2.20E-01	2.59E+02
Pu-240	1.14E+00	1.47E+00	9.76E+00	6.77E-03	6.84E+00	8.00E-02	8.00E-02	8.00E-02	1.47E-02	NS[b]	1.95E+01
Tc-99	4.37E+00	1.16E+01	2.28E+01	NS[b]	2.69E+00	3.50E-01	3.50E-01	3.50E-01	6.36E-02	NS[b]	4.26E+01
U-234	4.57E+00	1.55E-01	6.46E-01	1.35E-01	9.59E-01	6.00E-03	6.00E-03	6.00E-03	7.82E-04	3.00E-02	6.51E+00
U-238	1.48E+00	4.55E-04	1.56E-02	1.07E-01	8.71E-01	2.42E-05	2.42E-05	2.42E-05	1.11E-05	1.70E-04	2.47E+00

a. Note that this is the estimated inventory in the surface sediments, not the inventory that is placed in the aquifer.

b. NS—Not sampled.

c. As discussed above, the Np-237 inventory from the INTEC disposal well is 100 times smaller than that used in the ICDF CA.

Table 2-18. Fraction of each sources contribution to the ICDF CA inventory.

CA COCs	ICDF Landfill	TFF Closure	Bin Sets	INTEC Disposal Well	INTEC CERCLA Contaminated Soil Sites	WCF	NWCF	PEWE	CPP-601	CPP-603
Am-241	0.09	0.01	0.31[a]	0.00	0.57	0.00	0.00	0.00	0.01	0.00
C-14	0.00	1.00	0.00	NS[b]	NS[b]	NS[b]	NS[b]	NS	0.00	NS[b]
I-129	0.39	0.00	0.00	0.55	0.05	NS[b]	NS[b]	NS	0.01	NS[b]
Np-237	0.15	0.00	0.73	0.00	0.11	0.00	0.00	0.00	0.00	0.00
Pu-239	0.02	0.01	0.93	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Pu-240	0.06	0.08	0.50	0.00	0.35	0.00	0.00	0.00	0.00	NS[b]
Tc-99	0.10	0.27	0.54	NS[b]	0.06	0.01	0.01	0.01	0.00	NS[b]
U-234	0.70	0.02	0.10	0.02	0.15	0.00	0.00	0.00	0.00	0.00
U-238	0.60	0.00	0.01	0.04	0.35	0.00	0.00	0.00	0.00	0.00

a. Major contributors are highlighted in yellow.

b. NS—Not sampled or reported.

The PA for the TFF closure is currently under revision, and the inventory and source term estimates are being revised (Section 2.5.2). The conservative revised TFF closure PA inventory estimates are based on a conservative estimate of the residual contamination in the tanks. The conservative inventory estimates are up to an order of magnitude greater than the inventories used for the simulations presented in this report. However, one tank has been cleaned and preliminary estimates of the residual inventory indicate that a much cleaner tank is achievable. Therefore, the TFF closure inventory is probably very conservative. When the new TFF closure PA has been reviewed and approved, or better information is available based on estimates of cleaned tanks, the ICDF CA simulations will be repeated using the updated inventory and releases. The change in inventory is not expected to significantly impact the ICDF CA conclusions.

No C-14 or Tc-99 was reported as disposed of to the INTEC disposal well (Section 2.5.4). An inventory of C-14 and Tc-99 was present in the waste discharge, but it is not included in this analysis due to lack of source term data. The INTEC disposal well is a significant contributor to the inventory; however, the timeframe of the releases are offset in time from the ICDF landfill releases by 1000 years. Since C-14 and Tc-99 are mobile nuclides, they are not expected to be cumulative with the ICDF landfill-related dose.

The estimated discharges to the vadose zone from the INTEC disposal well are also included in CERCLA vadose zone model, so the discharges are also included in the CERCLA contaminated soils sections of this CA (Sections 2.5.4 and 2.5.5). This is conservative because it double-counts the estimated discharge to the aquifer for this CA by including it in both the disposal well source and the CERCLA contaminated soils source. The disposal well portion of the discharge to the vadose zone, rather than the aquifer, is unknown. It is necessary to make the conservative assumption because, for some contaminants, there are significant time separations for aquifer doses from sources directly to the aquifer and sources to the vadose zone. This conservatism is not expected to have a significant impact on the predicted doses.

There has been a reevaluation of a portion of the INTEC CERCLA soils inventories since 1997 (Jenkins 2000). The inventory used in the CERCLA evaluation as well as in this ICDF CA evaluation is larger than the newer estimates by a factor of 1.29 up to 17.38 (Section 2.5.5). However, no C-14 was estimated for either the CERCLA CPP-28 or CPP-31 estimates. In addition, no Am-241 or I-129 was estimated for the CERCLA CPP-28 inventory.

No C-14 or I-129 was reported in the WCF residual inventory (Section 2.5.6). Since the NWCF and PEWE inventories are assumed to be the same as the WCF, they have no C-14 or I-129 inventories as well. An inventory of C-14 and I-129 was present in the residual but it is not included in this analysis due to lack of source term data. As can be seen from Table 2-16, reported inventory from these sites are negligible and the C-14 and I-129 inventories would be negligible as well.

No inventory of C-14, I-129, Pu-240, or Tc-99 was reported for the CPP-603 residual (Section 2.5.8). An inventory of each of these nuclides will be present in the residual but they were not included in this analysis due to lack of source term data. As can be seen from Table 2-16, reported inventory from CPP-603 sites are negligible and the C-14, I-129, Pu-240, and Tc-99 inventories would be negligible as well.

2.6.2 Source Release Uncertainties

The source release models have a number of key assumptions. The primary assumptions are that the infiltration-reducing cover at the ICDF landfill will perform as designed for 1,000 years and that many of the facilities will stabilize the residual contamination using grout. Each of these assumptions provides a separation in time between aquifer dose contribution from the ICDF, INTEC disposal well, CERCLA soil contamination sources, and the grouted tanks. These assumptions imply that the facilities will be controlled over the design life so that no unforeseen circumstance will interfere with the design performance of the closed facilities.

In this CA, the assumption has been made that the grouted sources (TFF closure, bin sets, WCF, NWCF, PEWE, CPP-601, and CPP-603) are stabilized for 500 years. During this time, there is no infiltration through the grout and, therefore, no leaching of contaminants to the vadose zone. It is assumed that, after 500 years, the grout in the tanks and facilities would have the same hydrogeologic transport characteristics as the surrounding soil. However, chemical properties of the grout and concrete would remain unchanged. As discussed in the HLW&FD EIS (DOE 2002), studies have shown that cementitious materials (such as grout or concrete) can be expected to last for extended periods of time approaching 1,000 years or more (Poe 1998). Therefore, it is likely that the grout would retain its original hydraulic properties for much longer than the 500 years assumed in the analysis.

3. ANALYSIS OF PERFORMANCE

The purpose of the CA is to estimate the total dose a person may receive from the ICDF low-level waste facility *plus* any additional sources of radioactive contamination that are present nearby. Under DOE 5400.5, "Radiation Protection of the Public and the Environment," DOE activities may not result in doses to members of the public from all exposure pathways, except for doses from radon isotopes and radon decay products, that exceed 100 mrem in a year. In addition, the as-low-as-reasonably-achievable (ALARA) process must be implemented for all DOE activities that result in public doses. The public dose limits do not apply to doses from medical sources, consumer products, global fallout from past nuclear accidents and weapons tests, and naturally occurring radiation sources (unless the naturally occurring radiation sources were enhanced by DOE activity, in which case, a determination will be made on a case-by-case basis).

3.1 Overview of Analysis

In general, the CA uses the models, methods, and results from the performance assessment (DOE-ID 2003a) to estimate doses at specified compliance points from all radionuclide sources on the Site. Other radionuclide sources typically include currently operating facilities, residual contamination on land or in the aquifer, and other waste disposal facilities. The radionuclide inventories and source terms[e] to the vadose zone and aquifer were generally obtained from other studies of these facilities (Table 3-1). However, the level of detail varied between studies. In some cases, only radionuclide inventories were available and a source term to the vadose zone and aquifer had to be calculated. In other cases, the source term to the aquifer was provided and this source term could be used in the simulation with little or no modification.

Facilities that had a vadose zone source term but lacked a source term to the aquifer required a simulation of unsaturated transport (INTEC Tank Farm Facility). In this case, the vadose zone beneath the facility was assumed to be the same as the vadose zone below the ICDF. Facilities that lacked a vadose zone source term also required a simulation of radionuclide leaching from the source (INTEC bin sets, CPP-633, CPP-659, CPP-601, CPP-603, CPP-604). In these cases, leaching was calculated using a first-order leaching model similar to that used for the ICDF landfill and described in Section 3.4.3. The choice of a consistent unsaturated zone beneath INTEC for those facilities that lack aquifer source terms results in a consistent unsaturated transit time among the facilities. In particular, it assured that the contaminant arrival time in the aquifer was the same for the majority of the sites, and thereby maximizes the cumulative effect of contaminant plumes from different facilities. For the INTEC CERCLA contaminated soils, aquifer fluxes were provided (DOE-ID 1997, Appendix F) and these fluxes were put directly into the aquifer. In the case of CPP-3 (injection well), radionuclides were injected directly into the aquifer and, therefore, vadose zone transport was irrelevant.

A variety of final closure assumptions have been made for the facilities assessed in the CA. The choice of closure options may significantly influence the timeframe and rate at which radionuclides will be leached from the source areas. The closures planned for each of the contributing facilities are described in Section 3.2.2.

Since the ICDF cover is assumed to remain intact for 500 years, significant contribution of radionuclides from the ICDF to the aquifer begins after 1,000 years. Therefore, there is little source interaction with radionuclide plumes originating from the ICDF and other INTEC sources for the first 1,000 years following closure of the ICDF.

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e. In this context, the source term refers the flux of radionuclides (in Ci/yr) from one media to another. The vadose zone source term specifically refers to the flux of radionuclides from the waste form to the vadose zone. The aquifer source term specifically refers to the radionuclide flux from the vadose zone to the aquifer.

Table 3-1. Facilities, radionuclide inventories, and source terms included in the ICDF CA.

Facility	Year Releases Are Assumed to Begin	Source Term/Inventory	Closure Assumptions
ICDF	2018	Inventory and source term to the aquifer from DOE-ID (2003a) (ICDF PA)	Infiltration-reducing cover installed in year 2018 is assumed to last 500 years and degrade to background infiltration for undisturbed soils over the next 500 years (total failure in 1,000 years).
INTEC Tank Farm Facility (CPP-780–786)	2016	Inventory and source term to the vadose zone from DOE-ID (2002d) (Tank Farm CA)	Waste is grouted and left in place with no infiltration-reducing barrier. Grout is impermeable while intact, but fails after 500 years.
INTEC bin sets	2002	Inventory from DOE-ID (2002d) (Tank Farm CA), source term to vadose zone and aquifer calculated in this report	Waste is grouted and left in place with no infiltration-reducing barrier. Grout is impermeable while intact, but fails after 500 years.
INTEC CERCLA contaminated soils	1953	Inventory and source term to the aquifer from DOE-ID (1997) (OU 3-13 Comprehensive RI/FS)	Soils are not remediated and no infiltration-reducing cover is assumed.
INTEC disposal well (CPP-3)	1953	Inventory and source term to the aquifer from DOE-ID (1997) (OU 3-13 Comprehensive RI/FS)	The well was closed in 1983. Model accounts for all previous radionuclide disposals.
Waste Calcining Facility (WCF), Building CPP-633	2002	Inventory from DOE (2002) (High Level Waste EIS), source term to vadose zone and aquifer calculated in this report	Waste is grouted and left in place with no infiltration-reducing barrier. Grout is impermeable while intact, but fails after 500 years.
Process Equipment Waste (PEW), Building CPP-604	2002	Inventory from DOE (2002) (High Level Waste EIS), source term to vadose zone and aquifer calculated in this report	Waste is grouted and left in place with no infiltration-reducing barrier. Grout is impermeable while intact, but fails after 500 years.
New Waste Calcining Facility (NWCF), Building CPP-659	2002	Inventory from DOE (2002) (High Level Waste EIS), source term to the vadose zone and aquifer calculated in this report	Waste is grouted and left in place with no infiltration-reducing barrier. Grout is impermeable while intact, but fails after 500 years.
Fuel Processing Complex (CPP-601)	2002	Inventory from the preliminary draft INTEC environmental assessment,[a] source term to the vadose zone and aquifer calculated in this report	Waste is grouted and left in place with no infiltration-reducing barrier. Grout is impermeable while intact, but fails after 500 years.
Fuel Receipt and Storage Facility (CPP-603)	2002	Inventory from EDF-1962, source term to the vadose zone and aquifer calculated in this report	Waste is grouted and left in place with no infiltration-reducing barrier. Grout is impermeable while intact, but fails after 500 years.

a. Personal communication between J..M. McCarthy, BBWI, and J. S. Irving, BBWI, August 21, 2003, regarding unpublished document, "Preliminary Draft—Environmental Assessment and Deactivation Plan for Obsolete Spent Nuclear Fuel Processing, Storage, and Support Facilities at the Idaho Nuclear Technology and Engineering Center (INTEC)," DOE-EA-1244, U.S. Department of Energy Idaho Operations Office, September 1998.

The nine CA sources (excluding the ICDF landfill) are distributed around the INTEC facility, but all lie northeast of the ICDF landfill. Each has a different surface area extent from which the contaminants are transported to the aquifer. The conceptual model of radionuclide transport is discussed in Section 3.2. The groundwater pathway is the only dose pathway evaluated for this CA because it is the only pathway that is reasonably expected to result in cumulative doses from various CA sources. The pathways and scenarios are discussed in Section 3.3. The model GWSCREEN (Rood 1999) was used to simulate aquifer transport from each of the CA sources and methods of superposition were used to calculate the cumulative doses. The analysis methodology is discussed in Section 3.4. The predicted all-pathways dose results are presented and discussed in Section 3.5. The predicted groundwater protection results are presented and discussed in Section 3.6.

3.2 Conceptual Model of Radionuclide Migration

The conceptual model of radionuclide migration for the subsurface transport pathways are described in this section. The section begins with a conceptual model of the ICDF landfill and then discusses the other contributing sources to the ICDF landfill CA. The ICDF landfill and contributing sources are shown in Figure 3-1. The contributing sources marked by colored and shaded areas represent the area over which contaminants enter the aquifer. For example, the CERCLA soils are modeled based on the results of the INTEC Comprehensive RI/FS (OU 3-13). The large square in Figure 3-1 that is outlined with a black line represents the area over which the contaminant flux from the CERCLA soils enters the aquifer.

3.2.1 Conceptual Model of the ICDF Landfill

The ICDF landfill conceptual model is described in DOE-ID (2003a) (ICDF PA) and summarized here. The subsurface flow and transport conceptual model differs between the time the cover is assumed to remain intact (Figure 3-2) and after cover failure (Figure 3-3). While the cover remains intact, water flow through the waste is minimal (0.01 cm/yr); however, water draining around the cover is drawn underneath it at some depth below ground surface. Therefore, vadose zone water travel times are about the same with and without the cover. After failure of the cover, infiltration is assumed to gradually increase to the infiltration rate through undisturbed soils (1 cm/yr) over 500 years. The increase in infiltration rate results in an increase in waste leach rates. The conceptual model contains the following assumptions:

- Radionuclides remain contained within the disposal structure up to the time of closure of the facility in the year 2018. Radionuclides leached from the ICDF soils will be collected by the leachate collection system.
- A cover placed over the facility limits infiltration into the waste to 0.01 cm/yr (0.004 in./yr) for the first 500 years. After 500 years (year 2518), the cover deteriorates over the next 500 years and infiltration through the cover gradually increases to a background infiltration rate of 1 cm/yr (0.4 in./yr).
- The cover only restricts water flow through the waste. While the cover is in place, most moisture runs off the cover into the surrounding soil where it infiltrates. A small amount (0.01 cm/yr [0.004 in./yr]) passes through the cover and into the waste. The enhanced infiltration around the cover results in vadose zone water travel times that are equivalent to background vadose zone water travel times. (See Figure 3-2 and Figure 3-3 for the conceptual models during and after the period that the cover remains intact.)
- The waste is homogeneously mixed with soil.
- Radionuclides that leach from the waste soil travel vertically and mix instantaneously in a clay layer below the waste.

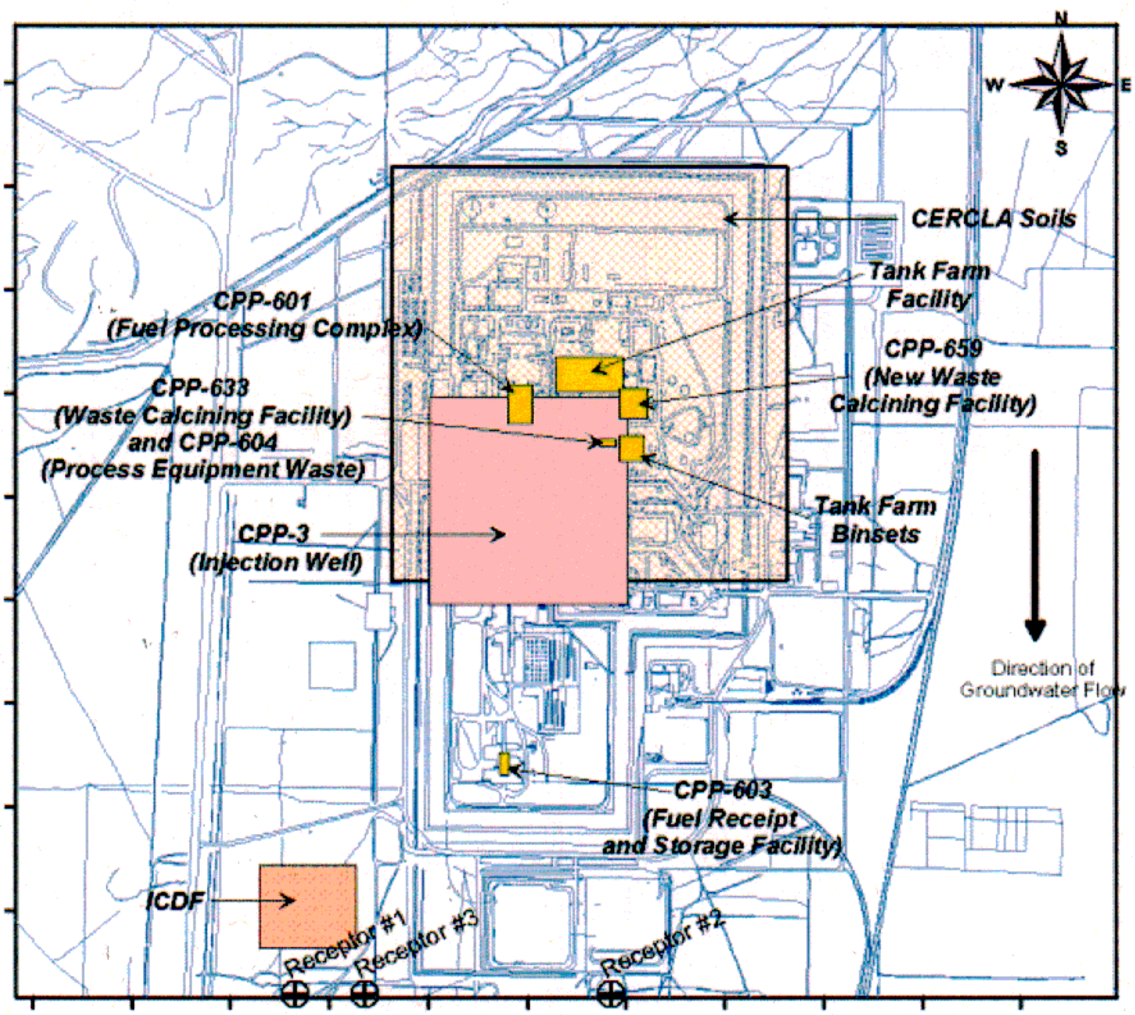

Figure 3-1. Location of the ICDF and other sources of radionuclides. Each rectangular area represents the area in which radionuclides enter the surface of the aquifer.

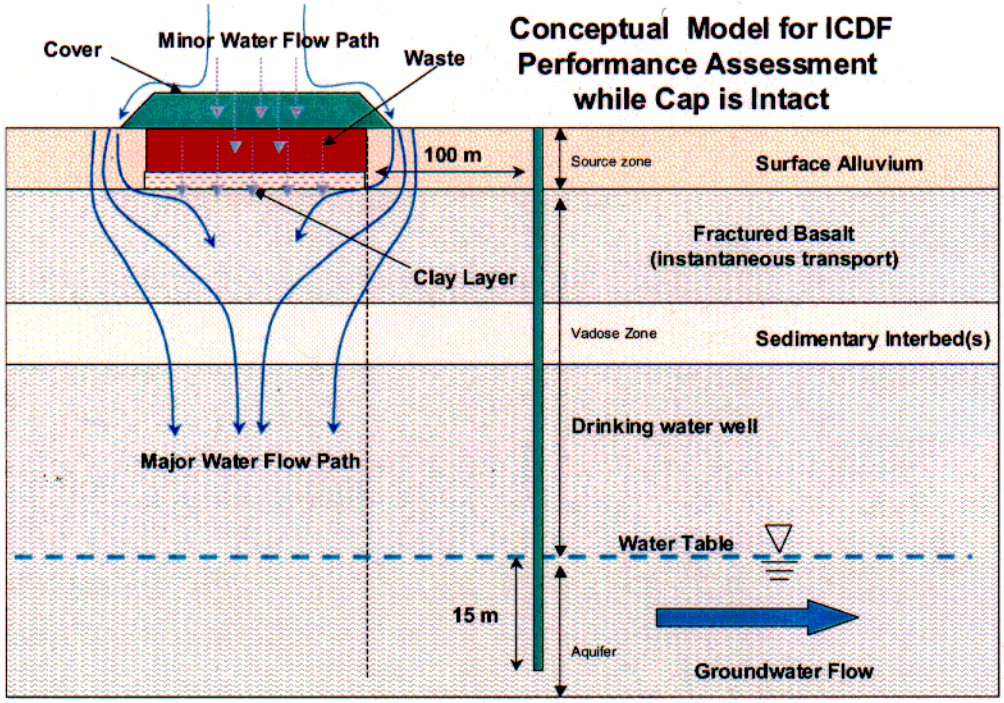

Figure 3-2. Conceptual model for the ICDF landfill performance assessment during the period in which the cover reduces infiltration to 0.01 cm/yr (before year 3018).

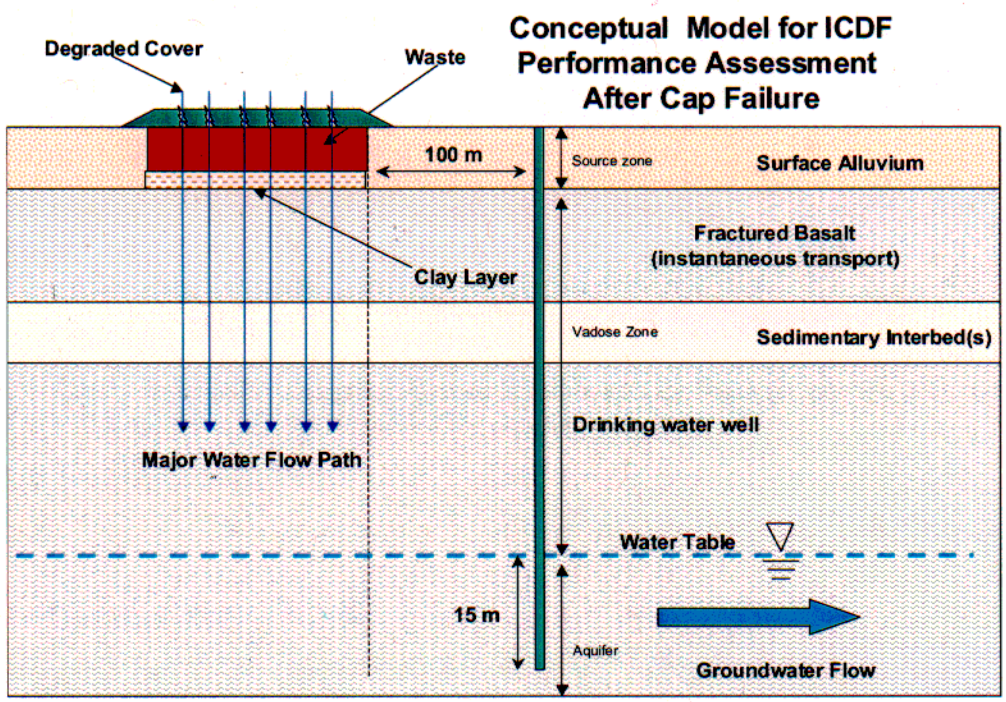

Figure 3-3. Conceptual model for the ICDF landfill performance assessment after the cover fails (after year 3018).

- Release from the waste and clay layer is described by first-order (leaching) processes.
- Vadose zone water travel times through fractured basalt are instantaneous, leaving only travel times through the sedimentary interbeds to influence the travel time of water and contaminants through the vadose zone to the aquifer.
- The aquifer is composed of an equivalent homogeneous, porous medium of infinite lateral extent and finite thickness.

3.2.2 Conceptual Model for the Other CA Facilities

The overall conceptual model for release and transport of radionuclides is illustrated in Figure 3-4. The conceptual model contains three basic components: a source compartment, unsaturated or vadose zone, and saturated zone or aquifer. Each component is linked to the adjacent one by the radionuclide flux between them. For example, the source compartment is linked to the vadose zone by the flux from the source compartment to the vadose zone. All transport is assumed to be downward (i.e., no upward flux from the unsaturated zone to the surface) until the aquifer is reached; transport is then horizontal in the aquifer.

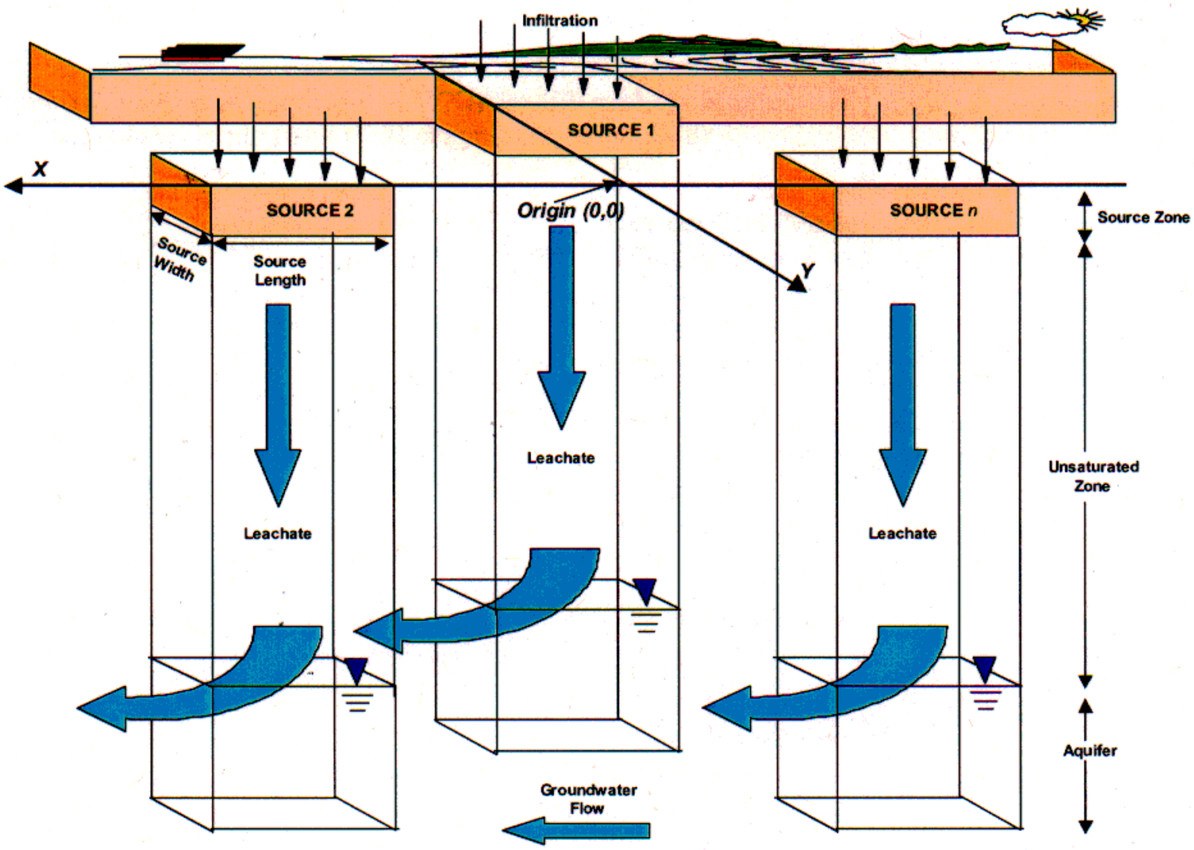

Figure 3-4. Conceptual model for release and transport of radionuclides from the other INTEC facilities for the ICDF CA..

Not all INTEC facilities considered in the CA required simulation of all three components because, for some facilities, source terms to the vadose zone or aquifer were provided. For convenience, each INTEC facility that was included in the CA was assigned to one of three facility types according to the state of source term development. These three types are defined by

- Type 1 facilities have radionuclide inventories but no source term to the vadose zone or aquifer.
- Type 2 facilities have a source term to the vadose zone.
- Type 3 facilities have a source term to the aquifer (Table 3-2).

The conceptual model for radionuclide release and transport in the vadose zone for each of the three types of facilities is discussed below.

3.2.2.1 Conceptual Model for Radionuclide Releases from the Source. The source model assumes the radioactivity release rate from the source is proportional to the amount of activity remaining in the source (first-order process). Inventories of radionuclides are assumed to be homogenously mixed in a volume defined by the length, width, and thickness of the source (source volume). Leaching of radionuclides from the soil is a function of the water infiltration rate, pore moisture content, and radionuclide partitioning between the sorbed and aqueous phases. Moisture content and infiltration are assumed to be spatially constant across the source volume, but may change with time. Partitioning between the aqueous and sorbed phase is described by the linear sorption coefficient, which is assumed to be constant within the source volume. Radioactive progeny are assumed to travel at the same rate as their parent.

This conceptual model applies only to Facility Type 1. The source term model for Facility Type 2 and 3 are described in the supporting documentation referenced in Table 3-1.

Table 3-2. Facility type designation for the INTEC facilities considered in the ICDF CA.

Facility	Facility Type[a]
ICDF	3
INTEC Tank Farm Facility (CPP-780–786)	2
INTEC bin sets	1
INTEC CERLA contaminated soils	3
INTEC disposal well (CPP-3)	3
Waste Calcining Facility (WCF), Building CPP-633	1
New Waste Calcining Facility (NWCF), Building CPP-659	1
Process Equipment Waste (PEW) (CPP-604)	1
Fuel Processing Complex (CPP-601)	1
Fuel Receipt and Storage Facility (CPP-603)	1

a. Type 1 facilities have radionuclide inventories but no source term to the vadose zone or aquifer; Type 2 facilities have a source term to the vadose zone; and Type 3 facilities have a source term to the aquifer.

3.2.2.2 Conceptual Model for Vadose Zone Transport. The vadose zone model assumes 1-dimensional vertical transport in a homogeneous isotropic porous medium. Infiltration and moisture content are assumed to be both temporally and spatially constant. Both advection and dispersion are accounted for. The advective component is described by the average linear pore water velocity through the vadose zone that is assumed to remain temporally constant. The dispersion coefficient is assumed to remain spatially and temporally constant. Radioactive progeny are assumed to travel at the same rate as their parent. An important feature of this model is that water mass balance between the source and vadose zone is not required; therefore, water fluxes from the source do not necessarily need to equal water fluxes through the vadose zone.

The subsurface environment beneath the INEEL is composed of basalt flows separated by sedimentary interbeds. The basalt flows are oftentimes fractured, allowing water to move freely in the vertical direction. Under such conditions, water travel times through the basalt are effectively instantaneous and result in water transport times through the entire vadose zone that are ultimately controlled by the presence of sedimentary interbeds. Therefore, only transport through sedimentary interbeds is considered when computing contaminant transport in the vadose zone.

The vadose zone conceptual model applies to Facility Types 1 and 2.

3.2.2.3 Conceptual Model for Aquifer Transport. The aquifer was assumed to represent a homogeneous isotropic porous medium of infinite lateral extent and finite thickness with a unidirectional and constant water flux flowing in the positive x direction (see Figure 3-4). Aquifer properties are therefore assumed to be the same across the entire INTEC site. Radionuclides entering the aquifer from the unsaturated zone mix with water in the aquifer over a depth defined by a typical well screen of 15 m (49 ft) and across an area defined by the length and width of the source. Water entering from the vadose zone to the aquifer is assumed not to influence the overall direction of flow in the aquifer but may influence the initial dilution below and downgradient from the source. Concentrations of radionuclides are assumed to be relatively dilute in the aquifer and, thus, travel independently downgradient from each INTEC source. The aquifer conceptual model applies to Facility Types 1, 2, and 3.

3.3 Pathways and Scenarios

This section describes the ICDF landfill CA receptor locations and the development of the exposure scenarios.

3.3.1.1 Receptor Locations. For the analyses, three receptors were defined along an east-west line, 100 m south of the ICDF landfill (Figure 3-1). The point of compliance per DOE M 435.1-1 is the point of highest projected dose or concentration beyond a 100-m buffer zone. These are defined as the potential receptor locations for the future hypothetical receptor. The west and east boundaries of the receptors are defined by the extent to which the ICDF landfill plume concentrations are maximized and other INTEC sources are maximized. A fourth receptor shown in Figure 3-5 is located 13 km downgradient from the ICDF landfill at the INEEL southern boundary and represents the point of compliance during the institutional control period (2018 – 2118).

3.3.1.2 Exposure Scenarios. Exposure scenarios are the link between contaminated environmental media and the exposure of a hypothetical receptor. They are essentially statements and parameter values that describe the physical characteristics and behavior of a hypothetical receptor. The all-pathways scenario (ingestion of contaminated drinking water, contaminated produce, and contaminated meat and dairy products) was the only dose pathway considered for this CA. Additional scenarios were evaluated in the ICDF landfill PA; however, only groundwater transport pathways are considered relevant in the CA.

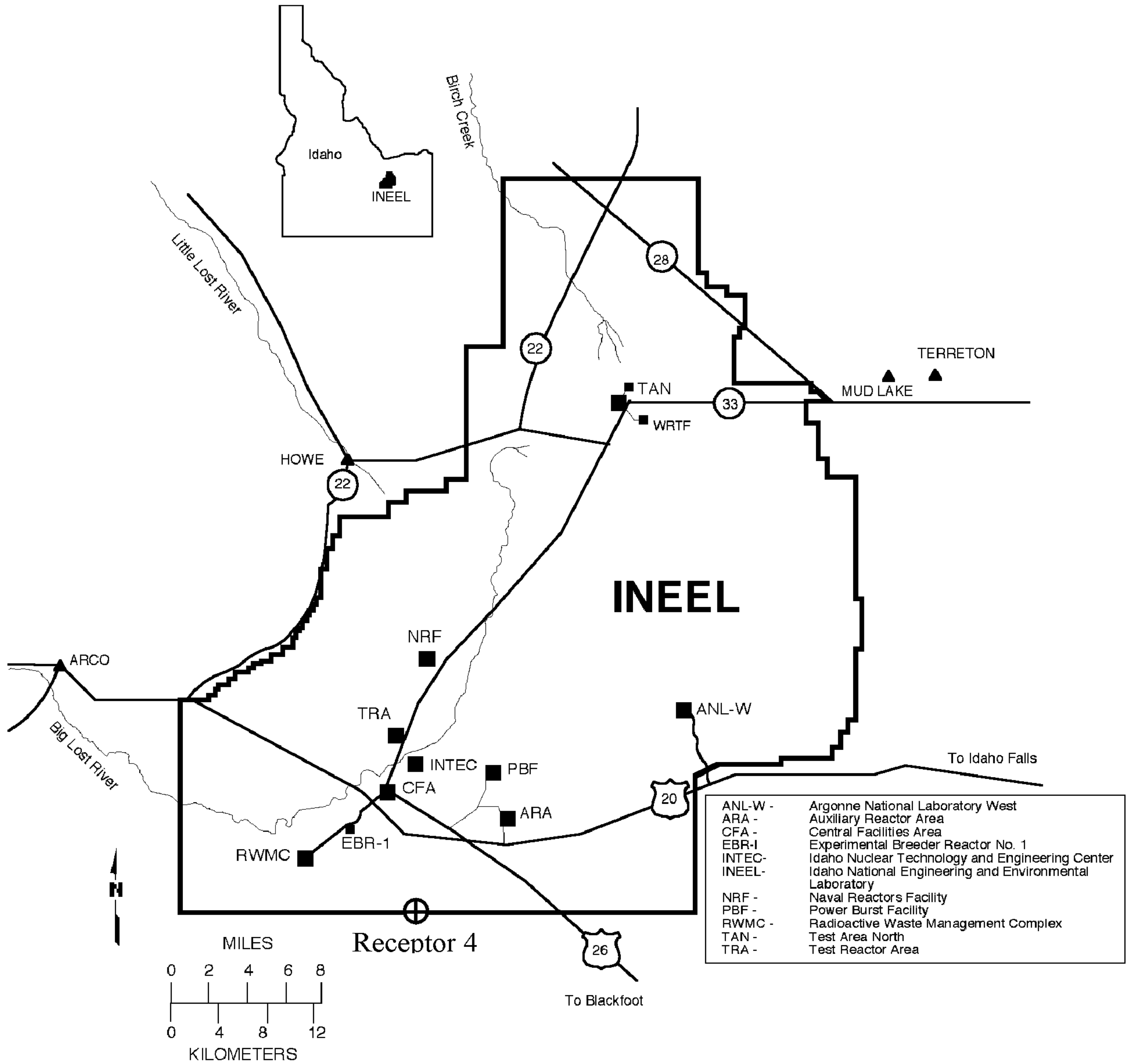

Figure 3-5. Location of the INEEL, major facilities, and Receptor 4 approximately 13 km downgradient of the INTEC and ICDF landfill, at the southern INEEL boundary.

The methodology used to calculate the all-pathways dose is based on the methodology presented in NRC (1977) and Peterson (1983). The all-pathways scenario assumes a receptor consumes (1) contaminated groundwater, (2) leafy vegetables and produce that were irrigated with contaminated groundwater, and (3) milk and meat from animals that consume contaminated water and pasture grass irrigated with contaminated groundwater. Details regarding the all-pathways scenario are documented in the ICDF Landfill PA (DOE-ID 2003a).

For evaluation of groundwater protection criteria, the receptor is assumed to consume 2 L of water per day for 365 days per year from a well that is impacted by contaminant plumes. This scenario is used to compute the dose from direct ingestion of man-made beta-gamma-emitting nuclides, which is then compared to the proposed maximum contaminant limit of 4 mrem/yr effective dose equivalent.

Additionally, gross alpha activity concentrations, Ra-226/Ra-228 activity concentrations, and total uranium mass concentrations are computed in this scenario.

3.4 Analysis Methodology

This section describes how the conceptual model discussed earlier is implemented such that quantitative estimates of groundwater concentrations and doses can be made.

3.4.1 Model Selection for Implementation of Conceptual Model

The computer model selected for the ICDF landfill PA and CA calculations was GWSCREEN Version 2.5 (Rood 1999). This model adapts well to the conceptual model for transport in the unsaturated and saturated zone. GWSCREEN was developed for assessment of the groundwater pathway from leaching of radioactive and nonradioactive substances from surface or buried sources. The code was designed for implementation in the Track 1 and Track 2 assessments of CERCLA sites identified as low probability hazard at the INEEL (DOE-ID 1994b). The code uses a mass conservation approach to model three processes: contaminant release from a source volume, vertical contaminant transport in the unsaturated zone, and 2 or 3-dimensional contaminant transport in the saturated zone. Optionally, the source term may be calculated external to GWSCREEN. In this case, fluxes to the vadose zone (or the aquifer) must be provided to GWSCREEN.

The computational framework for GWSCREEN has its roots in the methodology presented by the NRC (Codell et al. 1982; Kozak et al. 1990). Similar methodologies have also been employed in a number of other assessment codes including the Remedial Action Priority System (Whelan et al. 1996) and DECHEM (Killough et al. 1991). The groundwater transport model used in GWSCREEN has been used at the INEEL for scoping and assessment purposes (Codell et al. 1982; Rood et al. 1989).

GWSCREEN has been validated against other codes using similar algorithms and techniques (Smith and Whitaker 1993). The code was originally designed for assessment and screening of the groundwater pathway when field data are limited. Furthermore, GWSCREEN under simple conceptual systems is ideally suited for regulatory compliance calculations such as the ICDF landfill performance assessment and CA.

3.4.2 ICDF Landfill Source Term Release Model

The source term for the ICDF was calculated outside GWSCREEN and input into the code through a tabulated source function. The mathematical model for the source term is described in detail in the ICDF Landfill PA (DOE-ID 2003a) and is summarized here.

The model is based on a two-compartment, first-order kinetic model. A first-order model has the following limitations and assumptions:

- Contaminants entering the compartment are instantaneously mixed within the compartment.
- Release from the compartment is proportional to the amount of activity within the compartment and described by a first-order rate constant.

The two compartments considered in the model are the waste itself and the clay liner. The source term model provided radionuclide fluxes from the base of the clay liner to the top of the unsaturated zone. Leaching of waste from each compartment is a function of the infiltration rate and the sorptive characteristics of the radionuclide in both the waste and the clay liner. In general, clay sorption coefficients tend to be much higher than those for sand or silt. Prior to failure of the cover in 1,000 years, infiltration through the waste and the clay liner was assumed to be 0.01 cm/yr (0.004 in./yr). After failure of the cover, infiltration returns to the undisturbed soil background infiltration value of 1.0 cm/yr (0.4 in./yr).

3.4.3 Source Term Models for Other CA Facilities (Type 1 Facilities)

The governing equations for radionuclide release to the vadose zone are based on a single-compartment first-order kinetic model where the radioactivity release rate from the source is proportional to amount of activity remaining in the source. The governing equation is

$$\frac{dQ}{dt} = -(k + \lambda)Q \tag{3-1}$$

where

t	=	time (yr)
Q	=	total radioactive inventory in the waste compartment (Ci)
k	=	leach rate constant for waste compartment (yr^{-1})
λ	=	decay rate constant (yr^{-1}).

The solution to Equation (3-1) for the initial conditions, $Q = Q_o$ at $t = 0$ is

$$Q(t) = Q_o\, exp(-(k + \lambda)t) \tag{3-2}$$

And the flux ($F_s(t)$) from the waste compartment to the vadose zone is

$$F_s(t) = k\,Q_o\, exp(-(k + \lambda)t) \tag{3-3}$$

If the waste was grouted, then initial inventory (Q_o) was decayed for the time period the grout was assumed to remain intact (500 years).

$$Q(500) = Q_o\, exp(-\lambda\, 500\, y) \tag{3-4}$$

The flux from waste as a function of time from the end of remediation ($t = 0$) is then 0 Ci/yr for t ≤500 yr and

$$F_s(t) = k\,Q(500)\,exp(-(k + \lambda)(t - 500)) \tag{3-5}$$

for t > 500 years.

3.4.4 Vadose Zone Transport Model (Type 1 and 2 Facilities)

The flux to the aquifer (F_a) is given by a 1-dimensional solution to the advection-dispersion equation integrated over the release time.

$$F_a = \int_0^t F_s(\tau)\,\xi(t-\tau)\,d\tau \tag{3-6}$$

where ξ is given by

$$\xi = \frac{x + \dfrac{U_u t}{R_{du}}}{4\sqrt{D_{xu}\pi t^3 / R_{du}}} \exp\left[\frac{-\left(x - \dfrac{U_u t}{R_{du}}\right)}{4 D_{xu} t / R_{du}} - \lambda t \right] \tag{3-7}$$

and

U_u = unsaturated pore velocity (flow in the positive x direction, m/yr)

D_{xu} = dispersion coefficient in the x direction (m^2/yr)

x = vadose zone thickness (m)

R_{du} = retardation factor = $1 + K_d\,\rho/\theta$

K_d = sorption coefficient (mL/g)

ρ = bulk density (g/mL)

θ = moisture content.

Equation (3-7) is incorporated in the GWSCREEN model (Rood 1999) which was used to compute vadose zone transport and concentrations in the aquifer (see discussion in Section 3.4.1). Equations (3-3) through (3-5) were implemented in a spreadsheet for calculation of F_s as a function of time. Tabulated values of F_s were then output to ASCII files for input into GWSCREEN.

3.4.5 Model for Transport in the Aquifer

The saturated zone model is based on an analytic solution to the advection dispersion equation for contaminants in a saturated porous medium. This solution was originally implemented by Codell et al. (1982) and has been used for assessment of radionuclide transport in groundwater. This solution applies equally as well to nonradiological contaminants. The model contains the following assumptions and limitations:

- The model uses a Cartesian coordinate system (x,y,z) as a frame of reference. The positive x direction is in the direction of flow.
- The flow is uniform and unidirectional. No sources or sinks are accounted for.
- The aquifer is modeled as an isotropic, homogeneous porous medium of infinite lateral extent and finite thickness.
- Molecular diffusion is assumed to be negligible.

- The source can be represented by a rectangular area of length L and width W and centered at the origin (0,0,0).

- The dispersion coefficients remain constant over time.

- Transport is limited to a single specie that may decay or degrade as a function of time. Radioactive progeny are assumed to travel at the same rate as their parent.

- The contaminant is assumed to move as a dissolved substance. Transport in liquid organic and vapor phases are not considered.

- Solid and liquid phases are in equilibrium and concentrations are related by the linear distribution coefficient (K_d).

The mass balance equation that describes contaminant transport for the stated assumptions is

$$\frac{\partial C}{\partial t} + \frac{U}{R_d}\frac{\partial C}{\partial x} = \frac{D_x}{R_d}\frac{\partial^2 C}{\partial x^2} + \frac{D_y}{R_d}\frac{\partial^2 C}{\partial y^2} + \frac{D_z}{R_d}\frac{\partial^2 C}{\partial z^2} - \lambda\ C \qquad (3\text{-}8)$$

where

C	=	concentration (mg or Ci/m^3)
U	=	average linear velocity or groundwater pore velocity (m/yr)
$D_x\ D_y\ D_z$	=	dispersion coefficient in the x, y, and z direction (m^2/yr)
Rd	=	retardation factor in the aquifer
t	=	time (yr)
x	=	distance from center of area source to receptor parallel to groundwater flow (m)
y	=	distance from center of area source to receptor perpendicular to groundwater flow (m)
z	=	distance from the surface of the aquifer (m).

The retardation factor in the aquifer is given by

$$R_d = 1 + K_{da}\frac{\rho_a}{\eta} \qquad (3\text{-}9)$$

where

η	=	the effective porosity of the aquifer (m^3/m^3)
K_{da}	=	the distribution coefficient in the aquifer (mL/g)
ρ_a	=	the bulk density in the aquifer (g/cm^3).

The dispersion coefficients (D_x, D_y, D_z) are given by

$$D_x = \alpha_L U \quad D_y = \alpha_T U \quad D_z = \alpha_V U \tag{3-10}$$

where

α_L	=	the longitudinal dispersivity (m)
α_T	=	the transverse dispersivity (m)
α_V	=	the vertical dispersivity (m).

The vertically averaged Green's function solution to Equation (3-8) for instantaneous release of mass M_a, at $t = 0$ at the surface of an area defined by L and W and initial concentration of zero everywhere in the model domain is given by

$$C(x,y,t) = \frac{M_a}{\eta R_d} \frac{1}{2L} \frac{1}{b} \left(erf\left(\frac{x + \frac{L}{2} - \frac{Ut}{R_d}}{\sqrt{\frac{4 D_x t}{R_d}}} \right) - erf\left(\frac{x - \frac{L}{2} - \frac{Ut}{R_d}}{\sqrt{\frac{4 D_x t}{R_d}}} \right) \right)$$
$$\times \frac{1}{2W} \left(erf\left(\frac{\frac{W}{2} + y}{\sqrt{\frac{4 D_y t}{R_d}}} \right) + erf\left(\frac{\frac{W}{2} - y}{\sqrt{\frac{4 D_y t}{R_d}}} \right) \right) e^{-\lambda t} \tag{3-11}$$

where

b	=	the well screen thickness or mixing depth (m)
M_a	=	the initial total mass in the volume defined by L × W × b
erf	=	the error function
L	=	length of source parallel to groundwater flow (m)
W	=	width of source perpendicular to groundwater flow (m).

The terms L and W represent the length parallel to groundwater flow and the width perpendicular to groundwater flow, respectively. For conservatism, the L and W terms are assumed to be the same as the actual length and width of each source illustrated in Figure 3-1. Therefore, there is the implicit assumption that water in the vadose zone only travels vertically, and transverse dispersion in the unsaturated zone is zero. For INTEC CERCLA contaminated soils, vadose zone transport was computed using a different model that incorporated 3-dimensional flow in the vadose zone. The surface area represented for this source (illustrated in Figure 3-1) represents the area in which radionuclides enter the surface of the aquifer and does not represent the actual area of the source on the ground surface.

For the 3-dimensional solution, Equation (3-11) is multiplied by Z_1.

$$Z_1 = \left(1 + 2\sum_{m=1}^{\infty} exp\left(\frac{m^2\pi^2 D_Z t}{b^2 R_d}\right) cos\left(m\pi\frac{z}{b}\right)\right) \tag{3-12}$$

where

z = receptor distance below the surface of the aquifer (m).

The 3-dimensional solution gives the concentration at a point specified by (x,y,z) in the aquifer. Often, the average concentration over a screened interval is more useful than concentration at a point. The average concentration over a screened well interval, b_w (from the surface of the aquifer to depth b_w), for the 3-dimensional solution is given by

$$C_{3Davg}(x,y,z,t) = \frac{\int_0^{b_w} C(x,y,z,t)dz}{b_w}. \tag{3-13}$$

Equations (3-12) and (3-13) were used for all sources except the injection well. Injection well sources were input at several depths in the aquifer and, for this source, radioactivity was assumed to be mixed completely in the 76-m (250-ft) aquifer depth. Therefore, Equation (3-11) was used to compute concentrations in the aquifer for injection well sources using a value of 76 m (250 ft) for b.

For an arbitrary release, the concentration may be found by the convolution integral (Equation (3-6)) replacing F_s with F_a (the flux to the aquifer), and where ξ is given by Equation (3-11).

To evaluate the movement of radioactive progeny, the model makes the simplifying assumption that radioactive progeny travel at the same rate as the parent. This assumption has been shown to be conservative (Codell et al. 1982) and greatly simplifies the calculations. The concentration of the ith progeny in a decay chain at the receptor location is

$$C_i = C_{parent}\frac{DIF_i\, R_{d_{parent}}}{DIF_{parent}\, R_{d_i}} \tag{3-14}$$

where

DIF_i = decay-ingrowth factor of the ith progeny

DIF_{parent} = decay-ingrowth factor of the parent

R_{di} = retardation factor of the ith progeny

$R_{d\,parent}$ = retardation factor of the parent

C_{parent} = groundwater concentration of the parent (Ci/m^3).

The decay ingrowth factor for an n member chain is given by (Scrable et al. 1974):

$$\mathrm{DIF}_i(t) = \frac{\lambda_i}{\lambda_1}\left[\left(\prod_{i=1}^{n-1}\lambda_i\right)\sum_{i=1}^{n}\frac{e^{-\lambda_i t}}{\prod_{\substack{j\neq i\\ j=1}}^{n}\left(\lambda_j-\lambda_i\right)}\right] \tag{3-15}$$

where

λ_1 = decay constant for the parent (yr)

λ_i = decay constant for the i^{th} progeny (yr)

t = time from waste emplacement or release to the source (yr).

3.4.5.1 Superposition of Sources. The concentration at a point, x_r, y_r is calculated by summing the concentration at the receptor location from all of the contributing CA sources. Each of the CA sources and receptor points is described in terms of the Universal Transverse Mercator (UTM) coordinates. The summation is calculated as follows:

$$C_T(x_r, y_r, z, t) = \sum_{i=1}^{i=9} C(x_{si} - x_r, y_{si} - y_r, z, t) \tag{3-16}$$

where

x_r = UTM east (x) coordinate of the receptor (m)

y_r = UTM north (y) coordinate of the receptor (m)

x_{si} = UTM east (x) coordinate of the center of the ith source where i = 1-9 (m)

y_{si} = UTM north (y) coordinate of the center of the ith source where i = 1-9 (m)

z = depth into the aquifer where the concentration is calculated (m)

t = time from the start of the simulation (1953).

3.4.6 Parameter Values for Subsurface Pathways Models

Parameter values used in the ICDF performance assessment simulation for the subsurface pathway are summarized in Table 3-3 for nuclide-independent parameters and Table 3-4 for nuclide-dependent parameters. Nuclide-independent parameters for the other facilities are listed in Table 3-5. Nuclide-specific values include sorption coefficients, ingestion DCFs and all-pathways DCFs. All-pathways DCFs include direct ingestion of well water and transfer of radioactivity to food products and are derived in the ICDF Performance Assessment (DOE-ID 2003a). Ingestion dose conversion factors (DCFs) were obtained from EPA (1988). Sorption coefficient values that were used in the INTEC modeling are presented in Appendix A of the ICDF Landfill PA (DOE-ID 2003a).

Table 3-3. Nuclide-independent parameter values for the ICDF PA simulation.

Parameter	Value	Reference/Comments
Source length (m)	160	EDF-ER-275, ICDF only.
Source width (m)	194	EDF-ER-275, ICDF only.
Source thickness (m)	12.56	EDF-ER-275, ICDF only.
Clay layer thickness (m)	0.9	EDF-ER-275, ICDF only.
Infiltration rate through cover and into waste, 0-500 years (cm/yr)	0.01	Applies only to the ICDF source term model. Infiltration through the vadose zone remains at its background rate of 1 cm/yr (EDF-ER-279).
Infiltration rate through cover and into waste, 500-1,000 years (cm/yr)	Linear increase from 0.01 to 1 cm/yr	Applies only to the ICDF source term model. Infiltration through the vadose zone remains at its background rate of 1 cm/yr.
Infiltration rate through cover, 1,000-∞ years or background infiltration rate (cm/yr)	1.0	Cover returns to estimated background infiltration after failure, ICDF only.
Infiltration in vadose zone 0-∞ (cm/yr)	1.0	Estimated background infiltration.
Bulk density in source (g/cm^3)	1.946	EDF-ER-275, ICDF only.
Bulk density - unsaturated zone (g/cm^3)[a]	1.359	EDF-ER-275.
Bulk density - clay layer (g/cm^3)	1.586	EDF-ER-275, ICDF only.
van Genuchten α (1/m) in waste	1.066	EDF-ER-275, ICDF only.
van Genuchten n in waste	1.53	EDF-ER-275, ICDF only.
Saturated hydraulic conductivity in waste (m/yr)	31.5	EDF-ER-275, ICDF only.
Total porosity of waste (m^3/m^3)	0.266	EDF-ER-275, ICDF only.
Residual moisture content of waste (m^3/m^3)	0.072	EDF-ER-275, ICDF only.
van Genuchten α (1/m) in clay	0.8	EDF-ER-275, ICDF only.
van Genuchten n in clay	1.09	EDF-ER-275, ICDF only.
Saturated hydraulic conductivity in clay (m/yr)	0.0315	EDF-ER-275, ICDF only.
Total porosity of clay (m^3/m^3)	0.39	EDF-ER-275, ICDF only.
Residual moisture content of clay (m^3/m^3)	0.07	EDF-ER-275, ICDF only
van Genuchten α (1/m) in unsaturated interbeds	1.066	EDF-ER-275.
van Genuchten n in unsaturated interbeds	1.523	EDF-ER-275.
Saturated hydraulic conductivity in interbeds (m/yr)[a]	21.3	EDF-ER-275.
Total porosity of interbeds (m^3/m^3)[a]	0.487	EDF-ER-275.
Residual moisture content of interbeds (m^3/m^3)[a]	0.072	EDF-ER-275.
Transverse dispersivity in aquifer (m)[a]	$\alpha \times 0.2$	Whelen et al. (1996) (α = longitudinal dispersivity).
Aquifer thickness (m)[a]	76	DOE-ID (1994b).
Well screen thickness (m)[a]	15	DOE-ID (1994b).
Darcy velocity in aquifer (m/yr)[a]	21.9	EDF-ER-275.
Porosity of aquifer (m^3/m^3)[a]	0.06	EDF-ER-275.
Bulk density of aquifer (g/cm^3)[a]	2.491	EDF-ER-275.
Receptor location 1 (meters south from center of source)	180	DOE PA Guidance. (DOE M 435.1-1)
Unsaturated thickness (m)[a]	22.7	Calibrated value.
Unsaturated dispersivity (m)[a]	2.92	Calibrated value.
Longitudinal dispersivity in the aquifer (m)	3.31	Calibrated value for ICDF, scale-dependent value for all other sources.
Vertical dispersivity in the aquifer (m)[a]	$\alpha \times 1.16 \times 10^{-3}$	Whelen et al. (1996) (α = longitudinal dispersivity).

a. These parameter values were also used for all other CA facilities where applicable.

Table 3-4. Nuclide-dependent transport parameters for all ICDF landfill CA sources.

Nuclide/Progeny		Half-Life (yr)	Number of Progeny	Waste K_d for Soils[a] (mL/g)	Waste K_d for Grout[b] (mL/g)	Interbed K_d[a,c] (mL/g)	Aquifer K_d[a] (mL/g)	Ingestion DCF[d] (rem/Ci)	All-Pathways DCF[e] (rem-m^3/Ci-yr)
Am-241		432	3	340	5,000 (as Np-237)	340	13.6	3.6E+06	2.8E+06
	Np-237	2.14×10^6		8		8	0.32	4.4E+06	3.4E+06
	U-233	1.59×10^5		6		6	0.24	2.9E+05	2.3E+05
	Th-229+D	7,430		100		100	4	4.0E+06	3.1E+06
C-14		5,730	0	0	10		0	2.1E+03	5.6E+03
I-129		1.57×10^7	0	0.1[f]	2.0	0.1[f]	0.004[f]	2.8E+05	4.50E+05
Np-237		2.14×10^6		8		8	0.32	4.4E+06	3.4E+06
	U-233	1.59×10^5		6		6	0.24	2.9E+05	2.3E+05
	Th-229+D	7,430		100		100	4	4.0E+06	3.1E+06
Pu-239		21,400	3	140	5,000	140	5.6	3.5E+06	2.7E+06
	U-235+D	7.04×10^8		6		6	0.24	2.7E+05	2.2E+05
	Pa-231	32,800		550		550	22	1.1E+07	8.1E+06
	Ac-227+D	21.8		450		450	18	1.4E+07	1.1E+07
Pu-240		6,570	4	140	5,000	140	5.6	3.5E+06	2.7E+06
	U-236	2.34×10^7		6		6	0.24	2.7E+05	2.2E+05
	Th-232	1.41×10^{10}		100		100	4	2.7E+06	2.1E+06
	Ra-228+D	5.75		100		100	4	1.4E+06	1.2E+06
	Th-228+D	1.91		100		100	4	8.0E+05	6.2E+05
Tc-99		2.13×10^5	0	0.2	1,000	0.2	0.008	1.5E+03	3.4E+03
U-234		2.44×10^5		6		6	0.24	2.8E+05	2.3E+05
	Th-230	75,400		100		100	4	5.5E+05	4.2E+05
	Ra-226	1,600		100		100	4	1.3E+06	1.1E+06
	Pb-210	22.3		100		100	4	5.4E+06	5.8E+06
U-238		4.47×10^9	4	6	2,000	6	0.24	2.7E+05	2.2E+05
	U-234	2.44×10^5		6		6	0.24	2.8E+05	2.3E+05
	Th-230	75,400		100		100	4	5.5E+05	4.2E+05
	Ra-226	1,600		100		100	4	1.3E+06	1.1E+06
	Pb-210	22.3		100		100	4	5.4E+06	5.8E+06

a. ICDF PA Appendix A, DOE-ID (2003a).

b. K_d grout values taken from DOE-ID (2001a).

c. The aquifer basalt K_d is always 1/25 the waste/interbed K_d.

d. Committed effective dose equivalent per unit intake ingested from EPA (1988). The "+D" designation include contributions from daughters.

e. All-pathways conversion factor includes short-lived progeny that are assumed to be in secular equilibrium with the parent in the environment.

f. This K_d is consistent with the RWMC PA and TFF PA values.

Table 3-5. Source release and aquifer flux parameter values for CA sources other than the ICDF landfill.

Parameter	INTEC Tank Farm Facility (CPP-780–786)	INTEC Bin Sets	INTEC CERCLA Contaminated Soils	INTEC Disposal Well (CPP-3)	Waste Calcining Facility (WCF) and PEWE, Building CPP-633	New Waste Calcining Facility (NWCF) Building CPP-659	Fuel Processing Complex (CPP-601)	Fuel Receipt and Storage Facility (CPP-603)
Source length (m)	70	50	800	400	15	58	74.4	42.9
Source width (m)	135	50	800	400	32	58	49.2	21.4
Source thickness (m)	N/A[a]	0.3048	N/A[a]	N/A[a]	4.6	0.00635	3	0.60
Infiltration[b] (m/yr)	0.01	0.01	N/A[a]	N/A[a]	0.01	0.01	0.01	0.01
Waste form[b]	N/A[a]	Grouted	N/A[a]	N/A[a]	Grouted	Grouted	Grouted	Grouted
Year starting simulation[c]	2116	2002	1953	1953	2002	2002	2002	2002
Waste form failure time	N/A[a]	500	N/A[a]	N/A[a]	500	500	500	500
Bulk density in source (g/cm^3)	N/A[a]	1.5	N/A[a]	N/A[a]	1.5	1.5	1.5	1.5
Moisture content in source	N/A[a]	0.3	N/A[a]	N/A[a]	0.3	0.3	0.3	0.3

a. N/A = Not applicable to CA modeling because fluxes to the vadose zone or aquifer were provided from other evaluations.

b. No releases are assumed from grouted waste forms before failure. The infiltration rate therefore only applies after waste form failure.

c. This is the year the simulation for a particular facility starts. Releases were rewritten for a starting year of 1953 for input into GWSCREEN. Releases prior to the year starting the simulation are zero.

Dispersivity values used for the ICDF at all receptor locations were the dispersivity values used in the ICDF performance assessment. These values were 3.31 m for the longitudinal dispersivity, 0.662 m for the transverse dispersivity (based on $\alpha_T = 0.2\ \alpha_L$ as described in Whelan et al. 1996), and 0.00384 m for the vertical dispersivity (based on $\alpha_V = 1.16 \times 10^{-3}\ \alpha_L$ as described in Whelan et al. 1996). Dispersivity values for all other sources were based on the scale-dependent dispersivity algorithms incorporated in GWSCREEN and derived from Xu and Eckstein (1996). The dispersion scheme selected gives a longitudinal dispersivity value at the distance to the Site boundary from the ICDF (~14 km [~9 mi]) of

$\alpha_L = 1.20\ [\log(1.4 \times 10^4\ \mathrm{m})]^{2.958} = 80.6$ m.

Transverse and vertical dispersivity were 0.2 and 1.16×10^{-3} times the longitudinal dispersivity in all cases.

3.4.7 Dose Calculations

The all-pathways dose was calculated by multiplying the groundwater concentration (Ci/m^3) by the all-pathways dose for a unit concentration ($rem\text{-}m^3/Ci\text{-}yr$), which yields the annual dose at the given time:

$$D_{ap} = DU_{ap} \times C \tag{3-17}$$

where

D_{ap} = the all-pathways dose (rem/yr)

DU_{ap} = the all-pathways dose for a unit concentration (rem-m^3/Ci-yr)

C = the groundwater concentration (Ci/m^3).

Drinking water doses were calculated by

$$D_{dw} = C \times 2\frac{L}{day} \times \frac{m^3}{1000\,L} 365 \frac{d}{year} \times DCF \qquad (3\text{-}18)$$

where

D_{dw} = the drinking water dose (rem)

C = groundwater concentration (Ci/m^3)

DCF = the ingestion dose conversion factor as given in Table 3-6 (rem/Ci).

The all-pathways and drinking water doses are calculated as the effective dose equivalent (EDE) from ingestion using dose conversion factors from EPA (1988). The EDE includes the 50-year committed effective dose equivalent. However, the 4 mrem/yr *committed dose equivalent* standard for beta-gamma-emitting radionuclides is calculated differently than the all-pathways dose. DCFs for the primary beta-gamma-emitters were back-calculated from the MCL data in 40 CFR 141 as shown below. These DCFs for beta-gamma-emitting radionuclides are based on the methodology in the National Bureau of Standards (NBS) Handbook 69 (DOC 1963). They were calculated using the MCLs reported in 40 CFR 141 (National Primary Drinking Water Regulations; Radionuclides; Notice of Data Availability; and Proposed Rule, Friday, April 21, 2000) and the exposure scenario used to determine the MCLs. The exposure scenario considers the ingestion of 2 liters of water per day for 365 days per year. The MCLs correspond to a concentration in drinking water that would yield a whole body or critical organ dose of 4 mrem/yr which may be written as

$$MCL = \frac{D_L}{C \times DCF \times I} \qquad (3\text{-}19)$$

where

D_L = the dose limit (4 mrem/yr CED)

C = the radionuclide concentration in water (pCi/L)

DCF = the dose conversion factor (mrem/pCi)

I = the water ingestion rate (730 L/yr).

Solving Equation 3-19 for DCF yields

$$DCF = \frac{D_L}{C \times MCL \times I} \quad . \qquad (3\text{-}20)$$

The DCFs for determining compliance with groundwater protection for beta-gamma-emitting radionuclide are shown in Table 3-6. Doses computed with the DCFs given in Table 3-6 were compared to the drinking water standard of 4 mrem/yr committed dose equivalent for beta-gamma-emitting radionuclides as promulgated in 40 CFR 141.

Table 3-6. Beta-gamma-emitting radionuclide committed dose equivalent conversion factors.

Radionuclide	MCL (pCi/L)	Committed Dose Equivalent Dose Conversion Factor (mrem/pCi)[a]
C-14	2,000	2.74E-06
I-129	1	5.48E-03
Tc-99	900	6.09E-06
Pb-210	1	5.48E-03

a. Back-calculated from the MCL using Equation 3-20.

3.5 All-Pathways Dose Results

The all-pathways doses were calculated at four primary receptor locations as shown in Figures 3-1 and 3-5. During the period of institutional control (2018–2118), the receptor is at the INEEL boundary. Afterwards, the receptor is assumed to be near the INTEC boundary. In order to verify that these four receptors bound the potential impacts for all receptor locations, the all-pathways dose at year 2118 was estimated for a series of wells (Figure 3-6) downgradient from INTEC to the boundary of the INEEL (Figure 3-7). As can be seen in Figure 3-7, in year 2118, the peak all-pathways dose is at the receptor closest to the INTEC. Therefore, after year 2118, the peak all-pathways dose will always be at Receptors 1, 2, or 3. In the remainder of this section, results will only be presented for Receptor 4 during the institutional control period and Receptors 1, 2, and 3 afterwards.

All-pathways doses as a function of time for the four receptor locations are illustrated in Figures 3-8 through 3-11 and summarized in Table 3-7. The results shown in Table 3-7 include the total all-pathways dose from the ICDF landfill and all other INTEC facilities. Figure 3-8 shows the predicted doses at Receptor 4 at the INEEL southern boundary. Receptor 4 is the receptor location for the institutional control period (period B in the figure), which is defined as year 2018 to 2118. Figures 3-9, 3-10, and 3-11 show the predicted doses at Receptors 1, 2, and 3 along an east-west line 100 m south of the ICDF landfill. Receptors 1, 2, and 3 are the receptor locations for the compliance period after institutional control (period C in the figures). The compliance period after the end of institutional control is from years 2118 to 3018.

As shown in Figure 3-7, during the institutional control and compliance periods the major contributors to the all-pathways dose are the INTEC CERCLA soils and the INTEC injection well (CPP-3). During the postcompliance period, the ICDF landfill and INTEC CERCLA soils make a significant contribution to the total dose around the year 4050. None of the other sources contribute an appreciable amount to the total all-pathways dose.

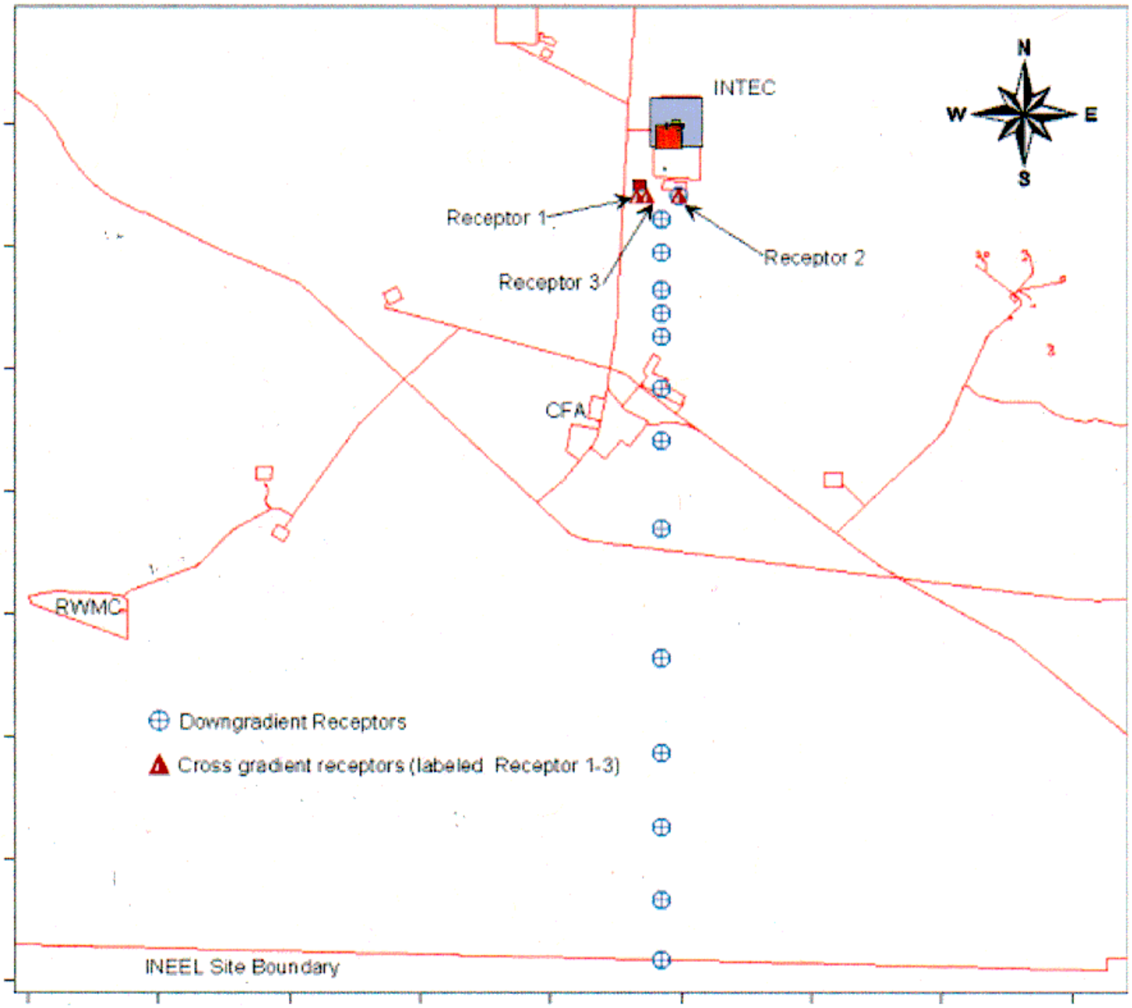

Figure 3-6. Map of the southern portion of the INEEL showing the location of the CA receptors. Cross-gradient receptors are labeled 1, 2, and 3.

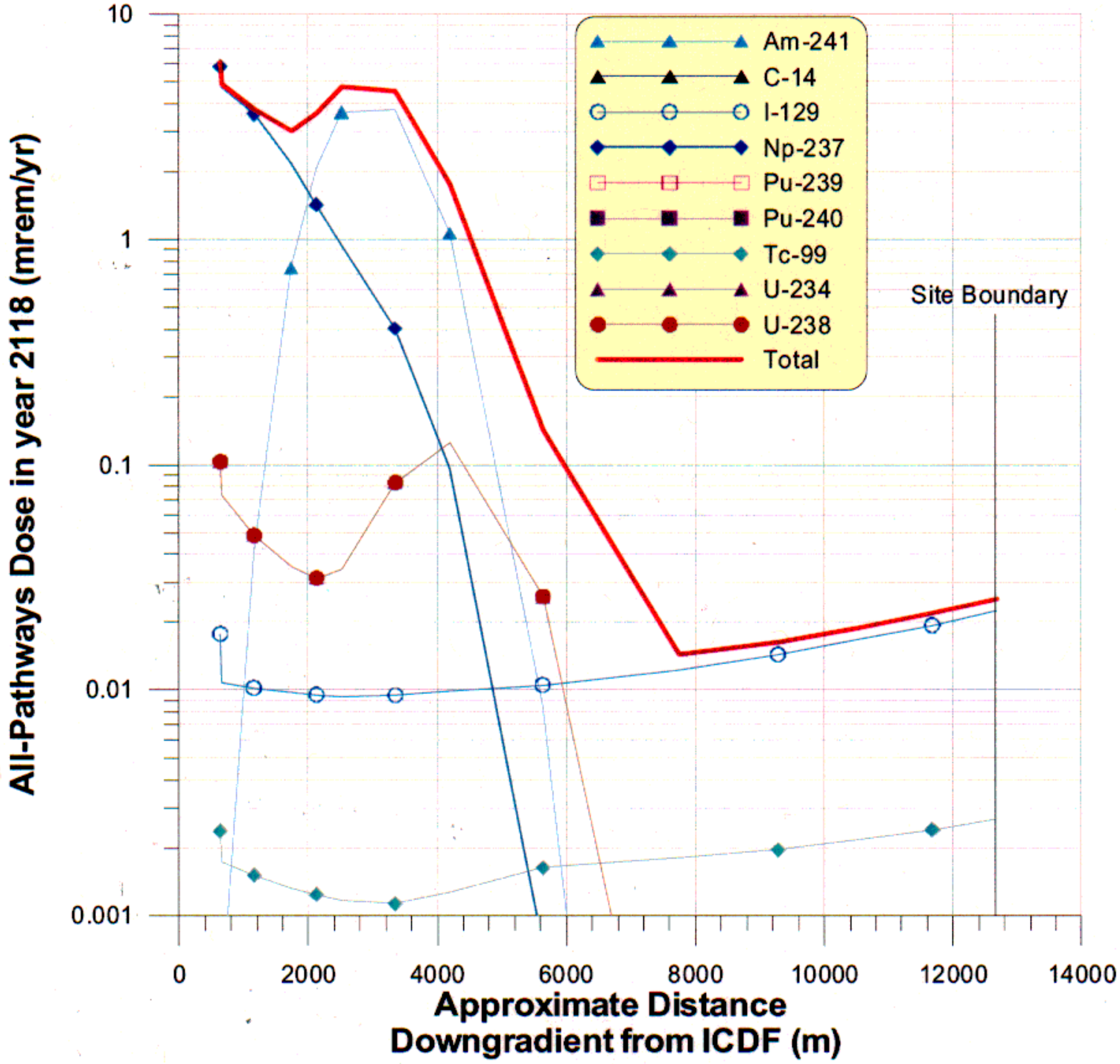

Figure 3-7. All-pathways dose as a function of downgradient distance from the ICDF landfill to the INEEL Site boundary in the year 2118.

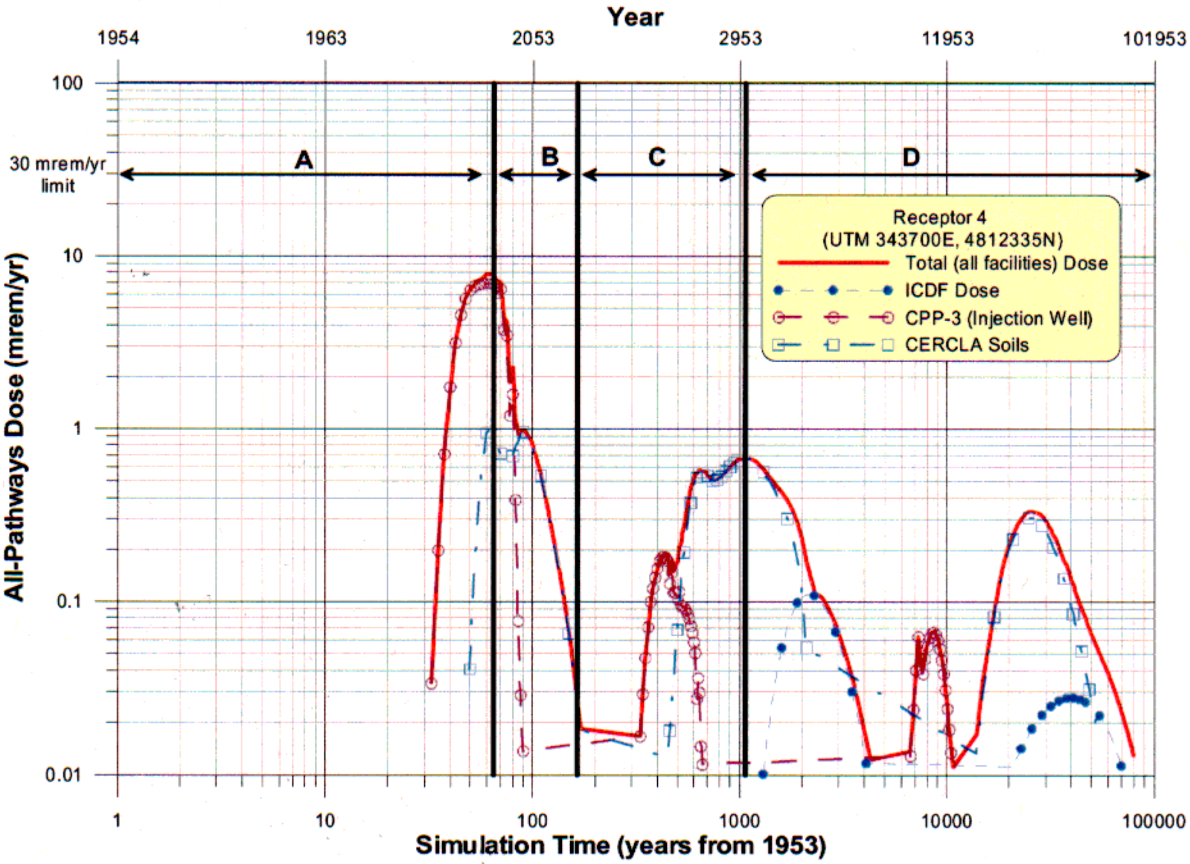

Figure 3-8. ICDF CA all-pathways dose results at Receptor 4.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

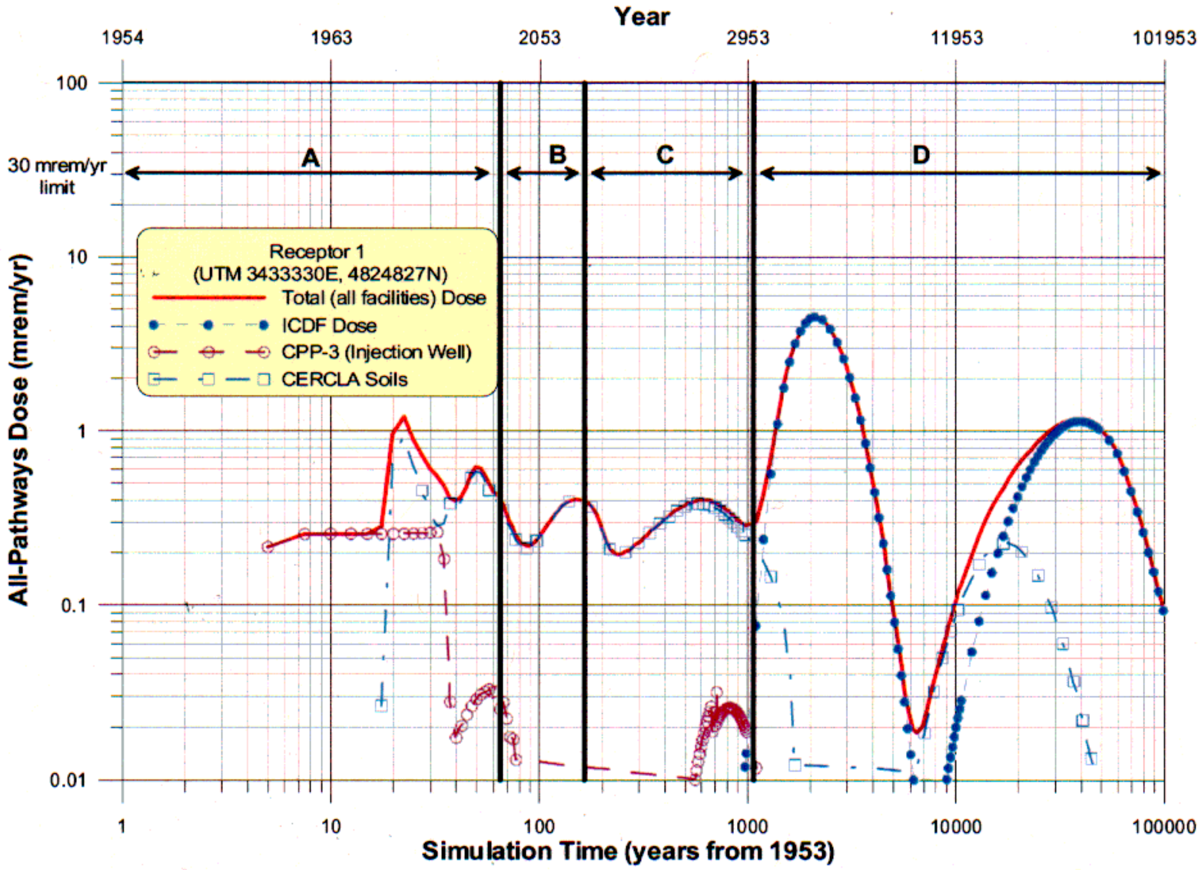

Figure 3-9. ICDF CA all-pathways dose results at Receptor 1.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

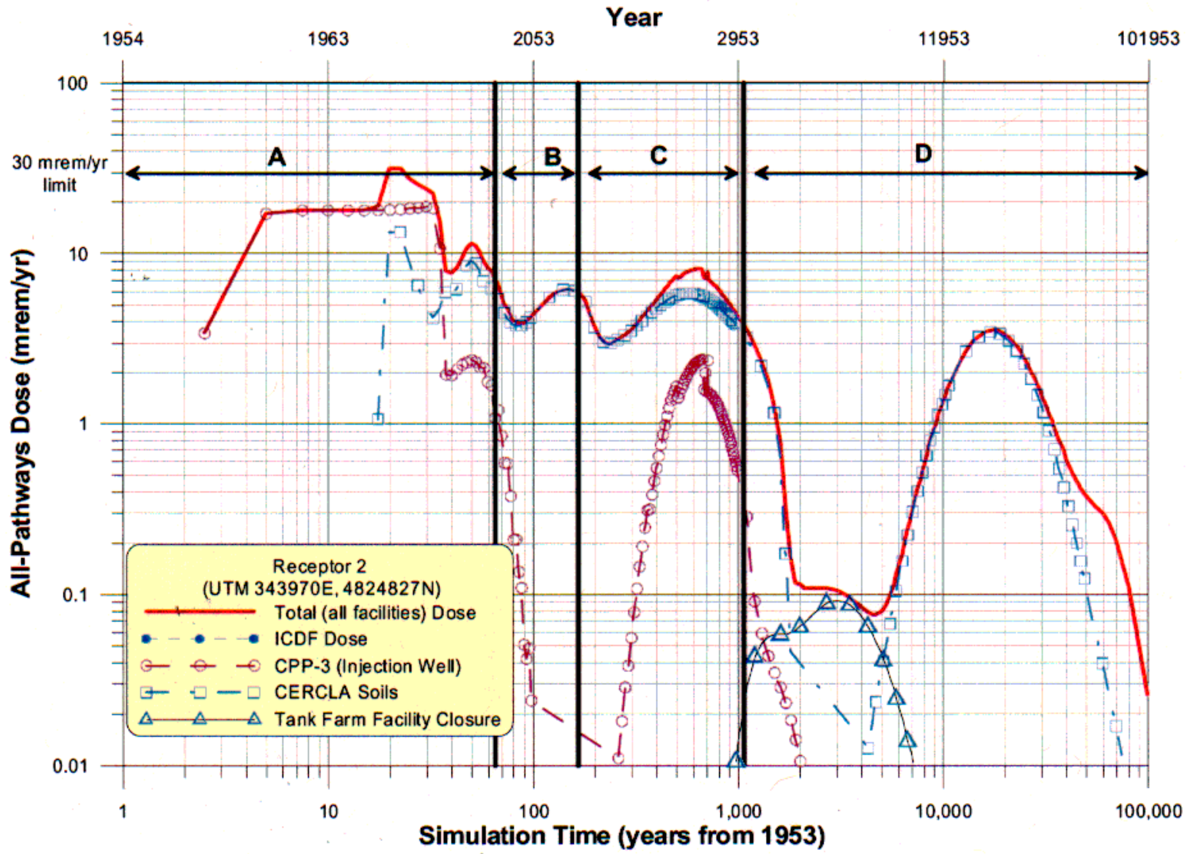

Figure 3-10. ICDF CA all-pathways dose results at Receptor 2.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

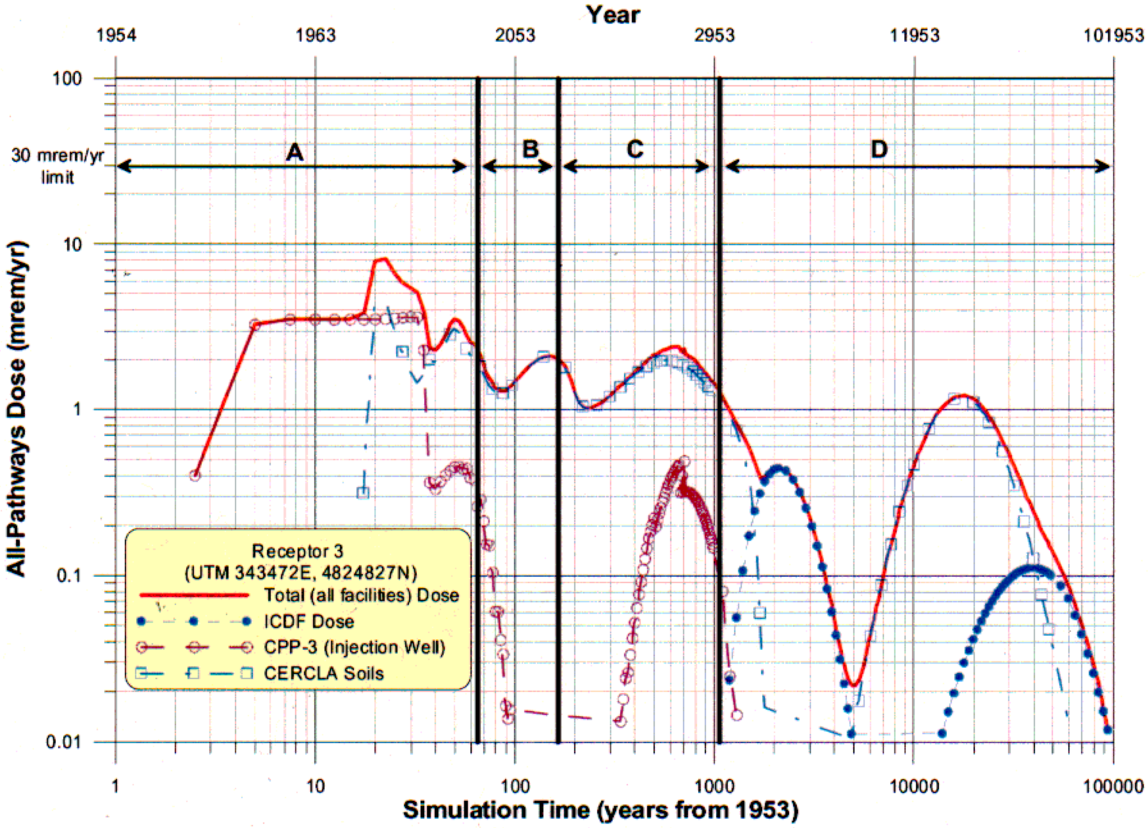

Figure 3-11. ICDF CA all-pathways dose results at Receptor 3.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

Table 3-7. Summary of the all-pathways dose analysis for the ICDF CA.

Timeframe			Receptor 4	
2018–2118	Year of maximum all-pathways dose		2018	
	Maximum all-pathways dose (mrem/yr)		7.80	
	Percent of dose from each source at time of maximum dose:			
	ICDF		0.00%	
	INTEC injection well (CPP-3)		88.03%	
	CPP-601		0.00%	
	CPP-603		0.00%	
	WCF (CPP-633)		0.00%	
	NWCF (CPP-659)		0.00%	
	Tank farm closure		0.00%	
	CERCLA soils		11.97%	
	Tank farm bin sets		0.00%	
	Radionuclide contributions at time of maximum dose:			
	Am-241		0.00%	
	C-14		0.00%	
	I-129		100.00%	
	Np-237		0.00%	
	Pu-239		0.00%	
	Pu-240		0.00%	
	Tc-99		0.00%	
	U-234		0.00%	
	U-238		0.00%	
Timeframe		Receptor 1	Receptor 2	Receptor 3
2118–3018	Year of maximum all-pathways dose	2583	2583	2593
	Maximum all-pathways dose (mrem/yr)	0.40	8.12	2.41
	Percent of dose from each source at time of maximum dose:			
	ICDF	0.04%	0.00%	0.00%
	INTEC injection well (CPP-3)	4.96%	28.43%	18.03%
	CPP-601	0.00%	0.00%	0.00%
	CPP-603	0.00%	0.00%	0.00%
	WCF (CPP-633)	0.00%	0.00%	0.00%
	NWCF (CPP-659)	0.00%	0.00%	0.00%
	Tank farm closure	0.00%	0.00%	0.00%
	CERCLA soils	95.00%	71.57%	81.97%
	Tank farm bin sets	0.00%	0.00%	0.00%

Table 3-7. (continued).

Timeframe		Receptor 1	Receptor 2	Receptor 3
	Radionuclide contributions at time of maximum dose:			
	Am-241	0.00%	0.03%	0.00%
	C-14	0.00%	0.00%	0.00%
	I-129	0.04%	0.00%	0.00%
	Np-237	71.71%	54.05%	61.99%
	Pu-239	4.38%	25.11%	15.94%
	Pu-240	0.58%	3.29%	2.09%
	Tc-99	0.00%	0.00%	0.00%
	U-234	12.50%	9.40%	10.71%
	U-238	10.80%	8.12%	9.27%
Timeframe		Receptor 1	Receptor 2	Receptor 3
3018–100,000	Year of maximum all-pathways dose	4053	19,953	19,953
	Maximum all-pathways dose (mrem/yr)	4.55	3.56	1.21
	Percent of dose from each source at time of maximum dose:			
	ICDF	99.99%	0.00%	2.46%
	INTEC injection well (CPP-3)	0.00%	0.00%	0.00%
	CPP-601	0.00%	0.00%	0.00%
	CPP-603	0.00%	0.00%	0.00%
	WCF (CPP-633)	0.00%	0.00%	0.00%
	NWCF (CPP-659)	0.00%	0.15%	0.00%
	Tank farm closure	0.00%	0.00%	0.00%
	CERCLA soils	0.00%	97.71%	97.53%
	Tank farm bin sets	0.00%	2.14%	0.00%
	Radionuclide contributions at time of maximum dose:			
	Am-241	0.00%	0.00%	0.00%
	C-14	0.00%	0.00%	0.00%
	I-129	98.07%	0.00%	0.00%
	Np-237	0.00%	2.07%	0.73%
	Pu-239	0.00%	83.82%	83.67%
	Pu-240	0.00%	13.89%	13.87%
	Tc-99	1.93%	0.00%	0.00%
	U-234	0.00%	0.21%	1.37%
	U-238	0.00%	0.00%	0.37%

The all-pathways doses in Table 3-7 are divided into three timeframes. The first timeframe is years 2018 through 2118, which represents the time period of institutional control and is evaluated at Receptor 4 at the INEEL southern boundary. The period from year 2118 to year 3018 represents the compliance period and the point of compliance is 100 m south of the downgradient edge of the source. The third time period is beyond year 3018. Key findings during each of the three time periods are summarized as follows:

- **Institutional Control:** During the institutional control period from the years 2018 through 2118, the all-pathways dose at the off-INEEL receptor (Receptor 4 in Figure 3-8) is predicted to be 7.8 mrem/yr for the ICDF CA. The primary nuclide contributor to the ICDF CA all-pathways dose during the institutional control period is I-129 from past wastewater disposal to the CPP-3 injection well. The predicted all-pathways dose is below the 100-mrem/yr compliance dose limit as well as the 30-mrem/yr options analysis dose limit.

- **Compliance Period:** During the compliance period from year 2118 through year 3018, Receptor 2 is the largest all-pathways dose contributor with a dose of 8.1 mrem/yr, and the doses predicted at Receptors 1 and 3 are 0.4 mrem/yr and 2.4 mrem/yr, respectively (Figures 3-9, 3-10, and 3-11 and Table 3-7). The primary nuclide contributors to the all-pathways dose during the compliance period are Np-237, Pu-239, U-234, and U-238. The predicted all-pathways doses are below the 100-mrem/yr compliance dose limit as well as the 30-mrem/yr options analysis dose limit.

- **Postcompliance Period:** After the compliance period has ended in year 3018, the peak doses predicted at Receptors 1, 2, and 3 are 4.6 mrem/yr, 3.6 mrem/yr, and 1.2 mrem/yr, respectively (Figures 3-9, 3-10, and 3-11 and Table 3-7). The primary nuclide contributors to the all-pathways dose during the postcompliance period are I-129, Pu-239, and Pu-240. The predicted all-pathways doses are below the 100-mrem/yr compliance dose limit as well as the 30-mrem/yr options analysis dose limit.

The all-pathways dose is projected to stay below the 100-mrem/yr performance standard and the 30-mrem/yr options analysis dose constraint for all three time periods of interest.

3.6 Groundwater Protection

Groundwater protection is evaluated by comparing predicted concentrations in the groundwater with MCLs for the respective radionuclides. Four types of concentrations are calculated: gross alpha concentration (excluding uranium and radon), Ra-226/Ra-228 concentration, committed dose equivalent (CDE) from beta-gamma-emitting radionuclides, and total uranium mass concentration. Note that the beta-gamma groundwater protection standard is CDE whereas the all-pathways dose is total effective dose equivalent (EDE). The EDE was calculated using dose conversion factors from Federal Guidance Report 11 (EPA 1988) whereas CDE values were calculated using data for the 168-hour week from National Bureau of Standards Handbook 69 (DOC 1963) and the current MCLs for beta-gamma nuclides in 40 CFR 141. Results are presented for Receptor 4 at the INEEL site boundary and Receptors 1 and 2 near INTEC. Results for Receptor 3 were not included because, in all cases, the results at Receptors 1 or 2 are larger.

Presented in Table 3-8 is a summary of the groundwater protection peak concentrations and doses. The results are discussed and concentration or dose versus time are presented in the following sections.

Table 3-8. Summary of the groundwater protection peak concentrations and doses.

	Gross Alpha Activity (pCi/L)	Ra-226/Ra-228 Activity (pCi/L)	Uranium Mass Concentration (ug/L)	Beta-Gamma CDE (mrem/yr)
Receptor 4, INEEL Site boundary—Institutional Control Period (2018–2118)				
Maximum concentration or dose	0.0E+00	0.0E+00	0.0E+00	6.9E+01
Year of maximum concentration or dose	NA[a]	NA[a]	NA[a]	2018
Receptor 1, Downgradient center of ICDF—Compliance Period (2118–3018)				
Maximum concentration or dose	1.1E-01	1.7E-05	6.2E-01	1.2E-01
Year of maximum concentration or dose	2123	2943	2483	2943
Receptor 1, Downgradient center of ICDF—Postcompliance Period (>3018)				
Maximum concentration or dose	2.1E-01	2.9E-02	1.6E+00	4.0E+01
Year of maximum concentration or dose	42,953	43,953	36,953	4053
Receptor 2, Downgradient center of INTEC—Compliance Period (2118–3018)				
Maximum concentration or dose	2.1E+00	2.6E-04	9.5E+00	1.9E-01
Year of maximum concentration or dose	2603	2943	2483	2943
Receptor 2, Downgradient center of INTEC—Postcompliance Period (>3018)				
Maximum concentration or dose	1.3E+00	5.7E-04	5.5E+00	5.4E-01
Year of maximum concentration or dose	18,953	32,953	3053	3353

a. NA = not applicable

3.6.1 Gross Alpha and Ra-226/Ra-228

The gross alpha and Ra-226/Ra-228 groundwater protection limits are 15 and 5 pCi/L, respectively. The predicted gross alpha and Ra-226/Ra-228 concentrations are shown in Figures 3-12 through 3-14 for Receptors 4, 1, and 2, respectively. The predicted concentrations are listed in Table 3-8 and summarized below:

- Institutional control period (years 2018–2118)—At the INEEL southern boundary (Receptor 4), the predicted peak gross alpha and Ra-226/Ra-228 concentrations are both zero pCi/L, respectively (see Figure 3-12). No radionuclides contributing to the gross alpha or Ra-226/Ra-228 concentrations are predicted to reach the INEEL boundary by year 2118.

- Compliance period (years 2118–3018)—At Receptors 1 and 2 (see Figures 3-13 and 3-14), the predicted peak gross alpha concentrations are 0.11 and 2.1 pCi/L, respectively. At Receptors 1 and 2, the predicted Ra-226/Ra-228 concentrations are less than 0.1 pCi/L at all receptor locations. These concentrations are less than the groundwater protection limits.

- Postcompliance period (years 3018–100,000)—At Receptors 1 and 2 (see Figures 3-13 and 3-14), the predicted peak gross alpha concentrations are 0.21 and 1.3 pCi/L, respectively. At Receptors 1 and 2, the predicted Ra-226/Ra-228 concentrations are 0.03 and 9.2E-04 pCi/L, respectively. These concentrations are less than the groundwater protection limits.

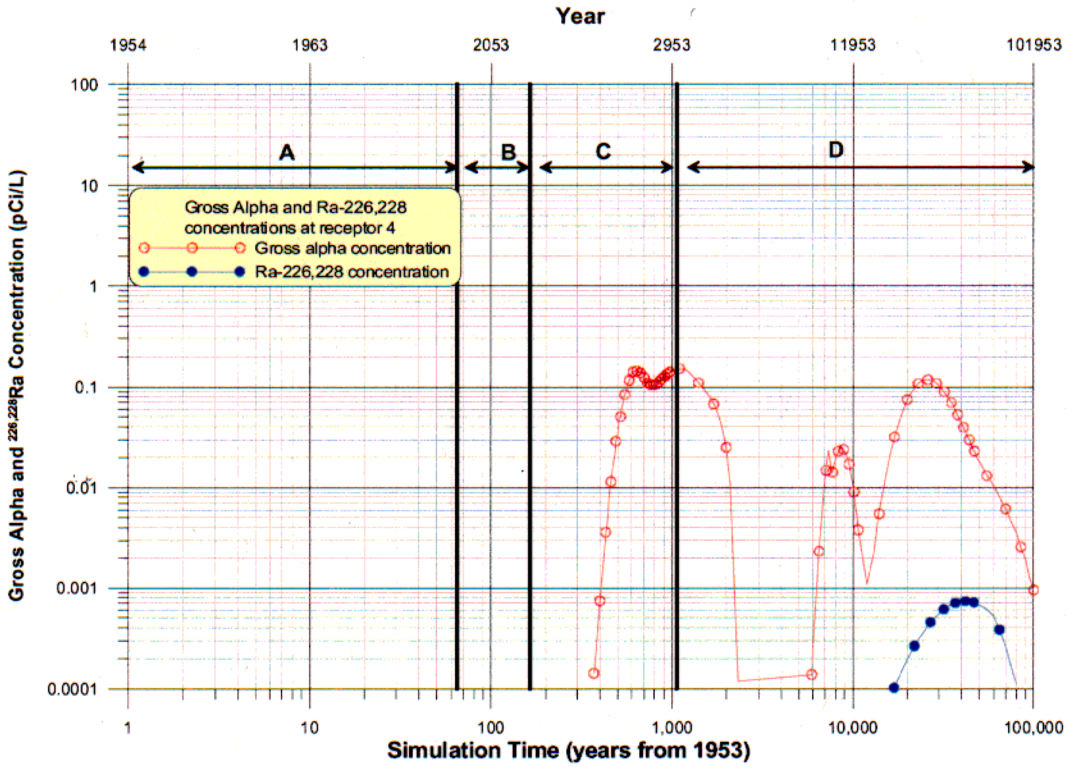

Figure 3-12. Gross alpha and Ra-226/Ra-228 concentrations in groundwater as a function of time at the INEEL Site boundary (Receptor 4).

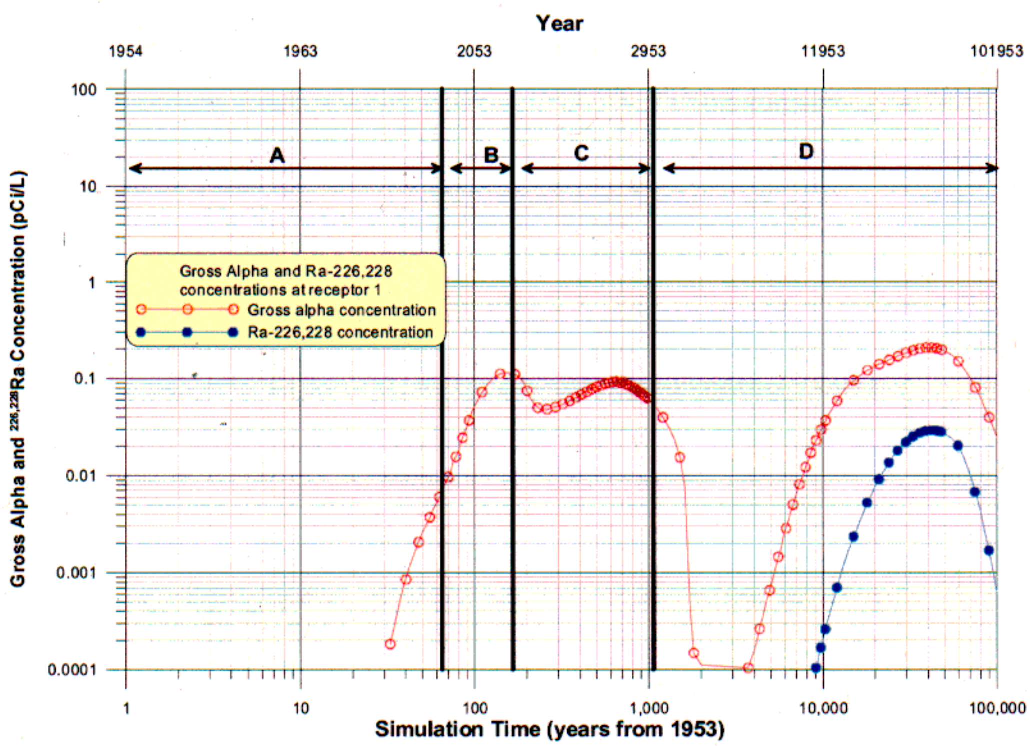

Figure 3-13. Gross alpha and Ra-226/Ra-228 concentrations in groundwater as a function of time at Receptor 1.

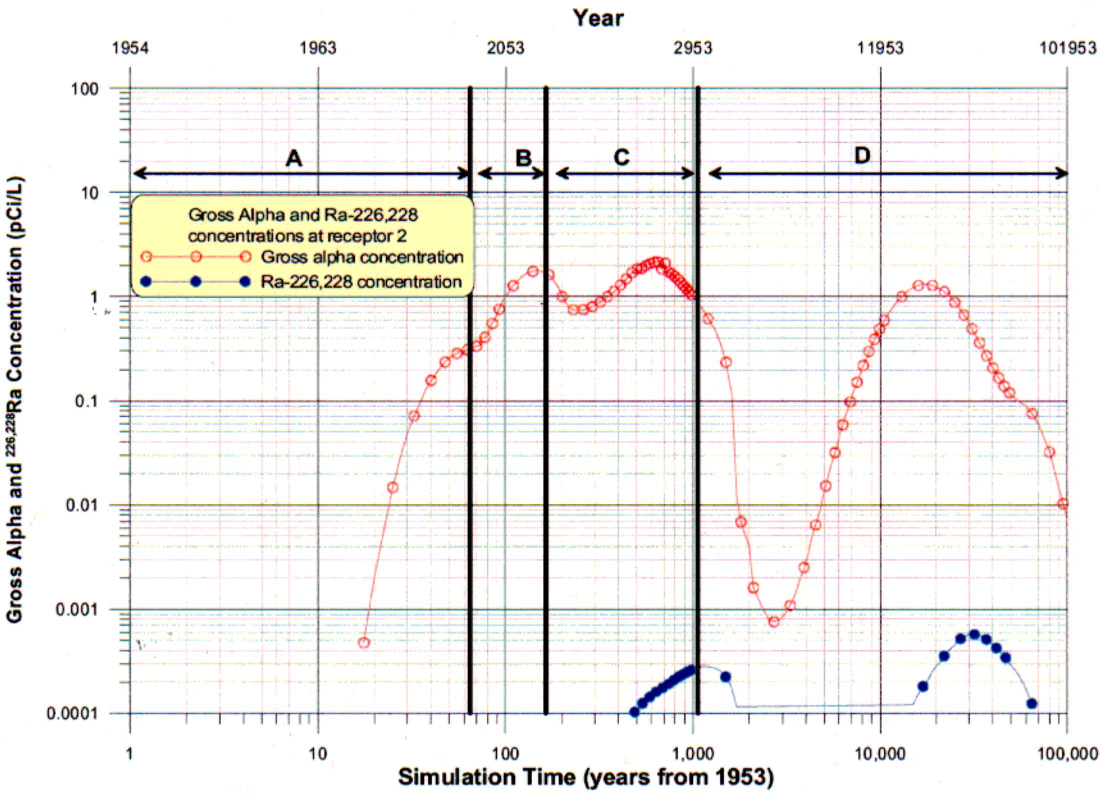

Figure 3-14. Gross alpha and Ra-226/Ra-228 concentrations in groundwater as a function of time at Receptor 2.

Note: All sources are included in the concentrations, although sources other than those from the ICDF landfill dominate the dose at this location.

3.6.2 Uranium Concentration

The groundwater protection total uranium concentration limit is 20 ug/L. The predicted total uranium concentrations are shown in Figures 3-15 through 3-17 for Receptors 4, 1, and 2, respectively. The predicted concentrations are summarized below for the following three time periods:

- Institutional control period (years 2018–2118)—At the INEEL boundary (Receptor 4), the predicted peak uranium concentration is zero ug/L. No uranium is predicted to reach the INEEL boundary by year 2118.

- Compliance period (years 2118–3018)—At Receptors 1 and 2, the predicted peak uranium concentrations are 0.62 and 9.5 ug/L, respectively. These values are less than the concentration limit of 20 ug/L.

- Postcompliance period (years 3018-100,000)—At Receptors 1 and 2, the predicted peak uranium concentrations are 1.6 and 5.5 ug/L, respectively. These values are less than the concentration limit of 20 ug/L.

3.6.3 Committed Dose Equivalent from Beta-Gamma

The beta-gamma groundwater protection dose limit is 4 mrem/yr committed dose equivalent. The doses were calculated using MCL data in 40 CFR 141, updated April 21, 2000. The predicted beta-gamma dose is shown in Figures 3-18 through 3-20 for Receptors 4, 1, and 2, respectively. The predicted concentrations are listed in Table 3-8 and summarized below:

- Institutional control period (years 2018–2118)—At the INEEL boundary (Receptor 4), the predicted peak beta-gamma dose is 69 mrem/yr (Figure 3-18). The predicted dose is a maximum in the year 2018 and falls to well below the 4 mrem/yr dose limit by the end of the institutional control period in year 2118. From year 2018 to about year 2060, the dose is predicted to be higher than the 4 mrem/yr limit. This predicted dose is from the I-129 in wastewater disposed to the INTEC disposal well. Significant doses have been predicted in past modeling studies as well (DOE-ID 1997) and, as a result of those predictions, new aquifer wells have been drilled at the INEEL and I-129 has become a primary COC driving aquifer sampling downgradient of the INTEC. The monitoring data do not support the predicted high doses of I-129. Based on sampling data, the peak dose in the aquifer is currently in the vicinity of the CFA and at a dose of 4 mrem/yr.

- Compliance period (years 2118–3018)—At Receptors 1 and 2, the predicted peak beta-gamma doses are 0.12 and 0.19 mrem/yr, respectively.

- Postcompliance period (years 3018-100,000)—At Receptors 1 and 2, the predicted peak beta-gamma doses are 40 and 0.54 mrem/yr, respectively. Most of the 40 mrem/yr dose is attributed to the predicted leaching of I-129 from the ICDF landfill.

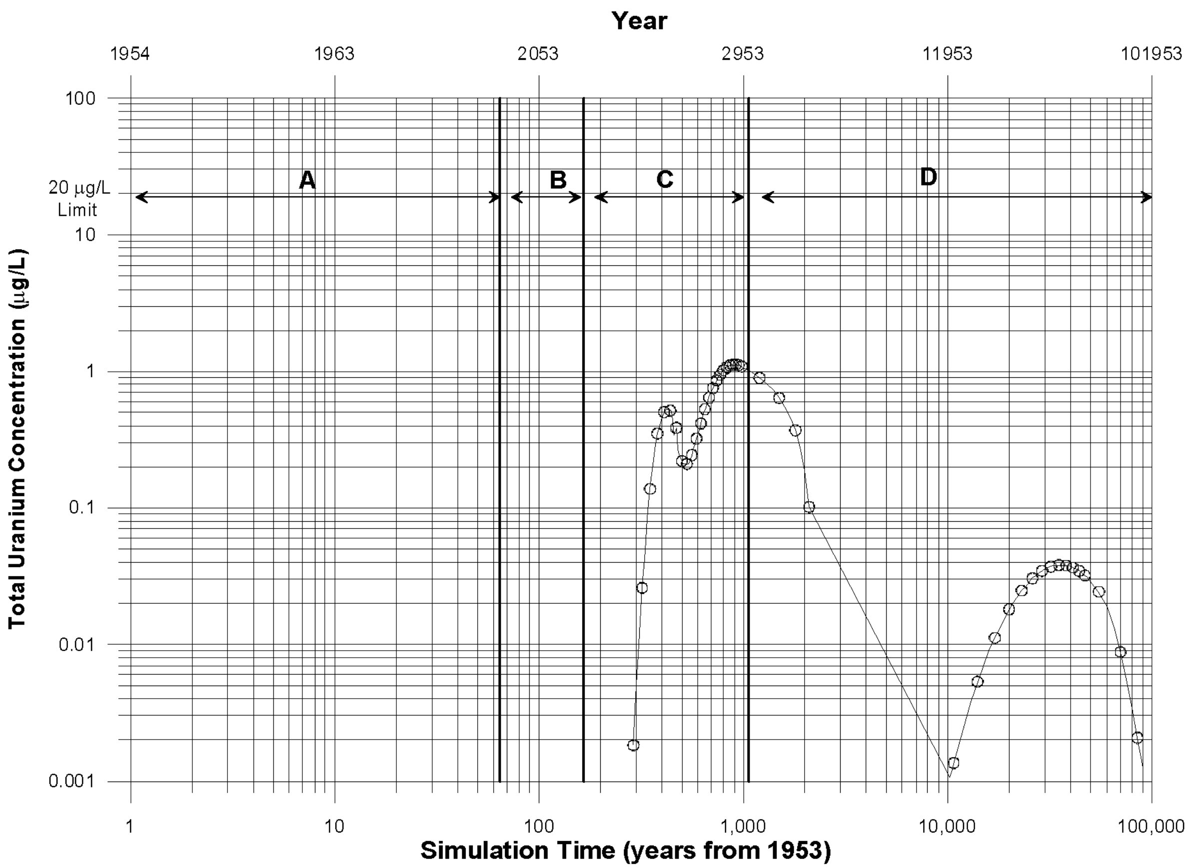

Figure 3-15. Uranium mass concentrations in groundwater as a function of time at the INEEL Site boundary (Receptor 4).

Note: All sources are included in the concentrations.

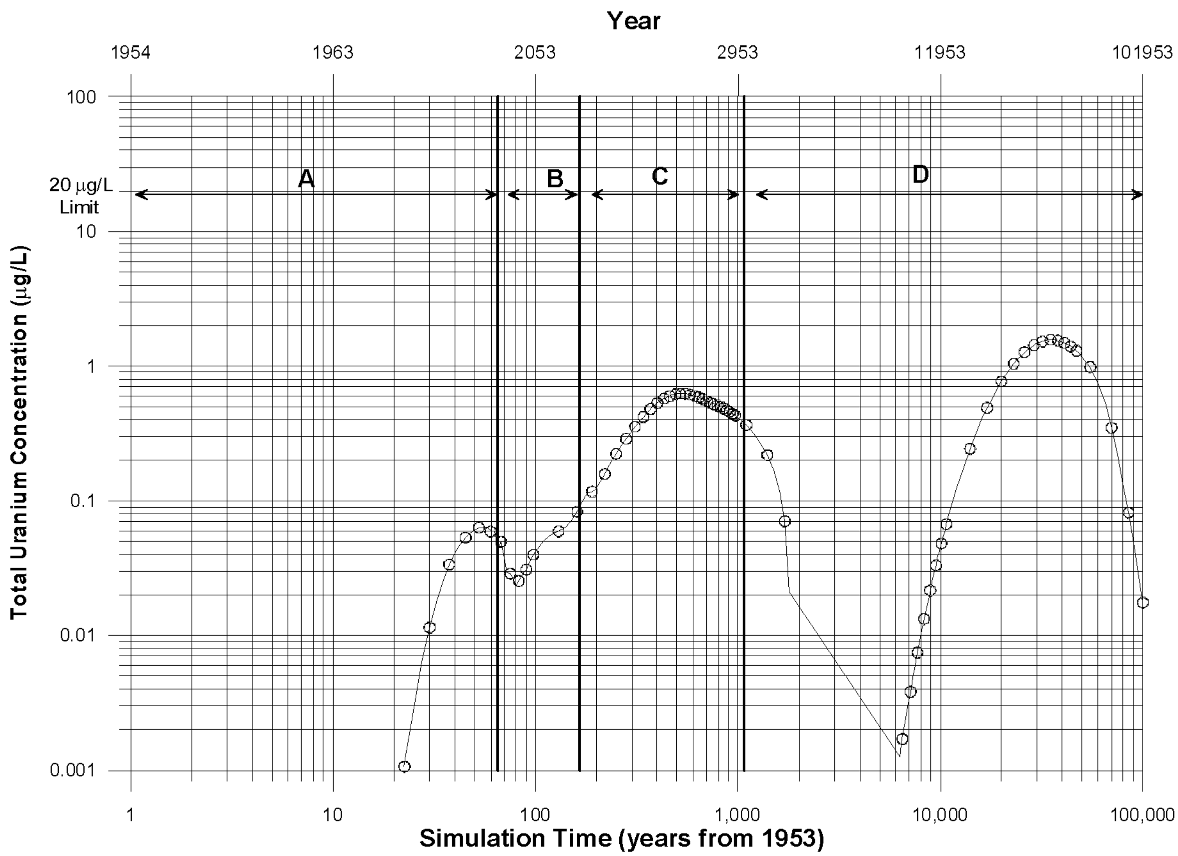

Figure 3-16. Uranium mass concentrations in groundwater as a function of time at Receptor 1 (located south from the center of the ICDF).

Note: All sources are included in the concentrations, although sources from the ICDF landfill dominate the dose at this location.

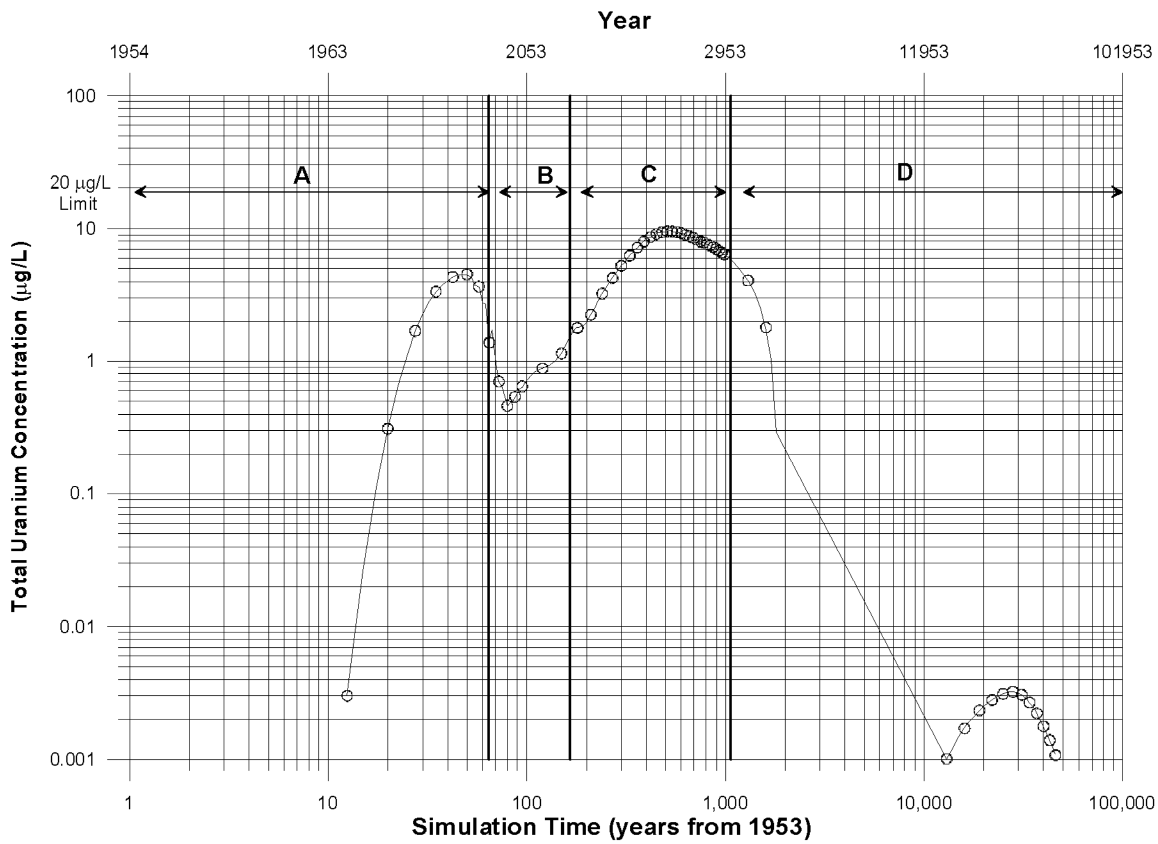

Figure 3-17. Uranium mass concentrations in groundwater as a function of time at Receptor 2.

Note: All sources are included in the concentrations, although sources from the ICDF landfill are minimal at this location.

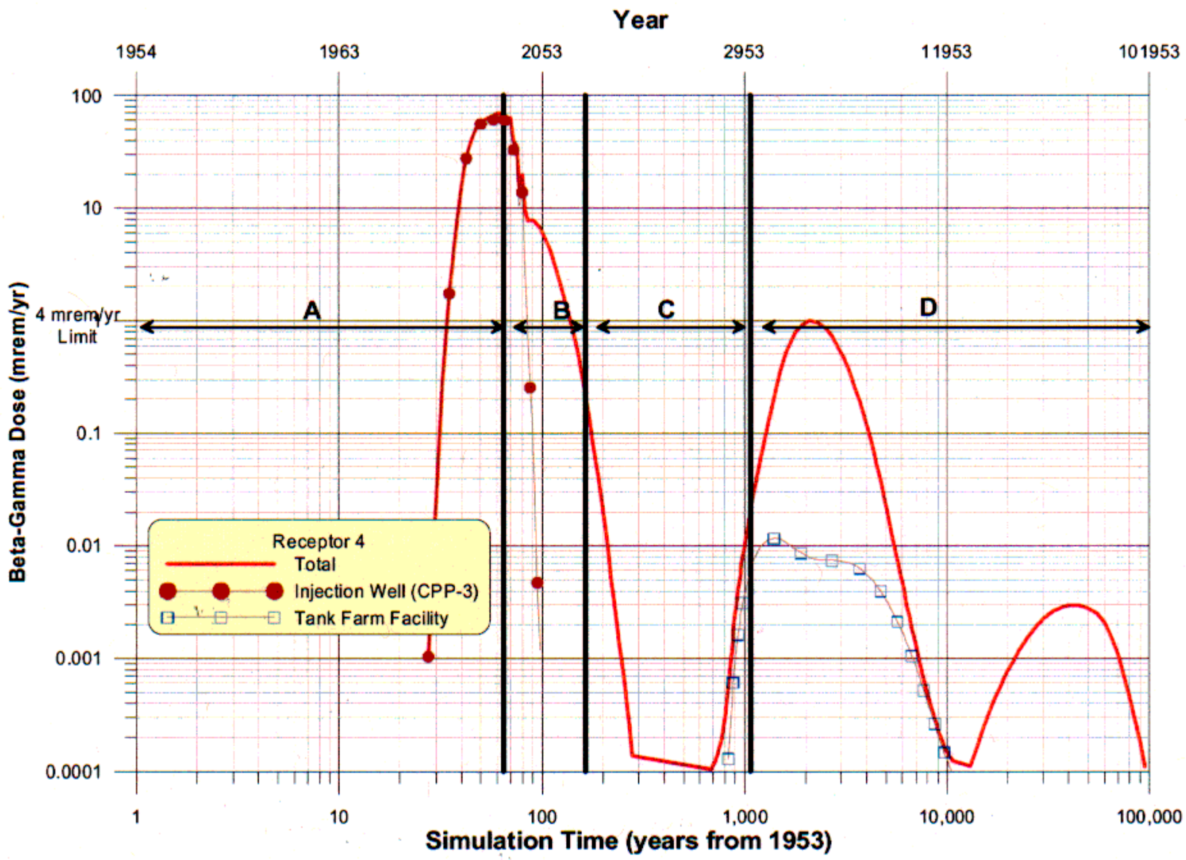

Figure 3-18. Committed dose equivalent from beta-gamma-emitting radionuclides as a function of time at the INEEL Site boundary (Receptor 4).

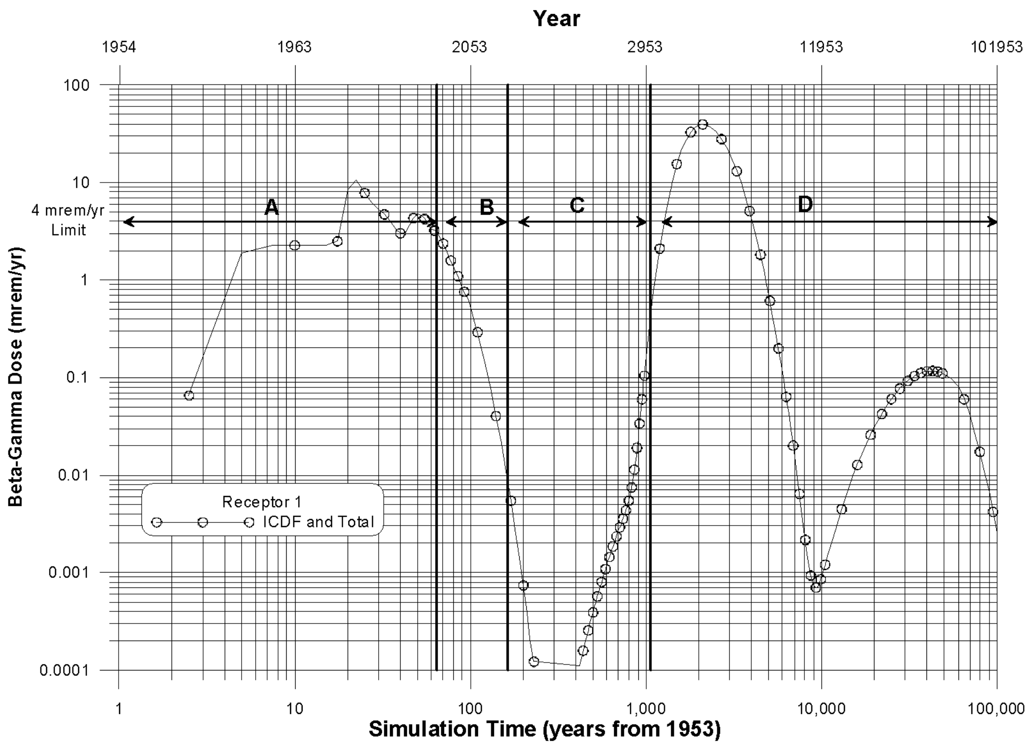

Figure 3-19. Committed dose equivalent from beta-gamma-emitting radionuclides as a function of time at Receptor 1.

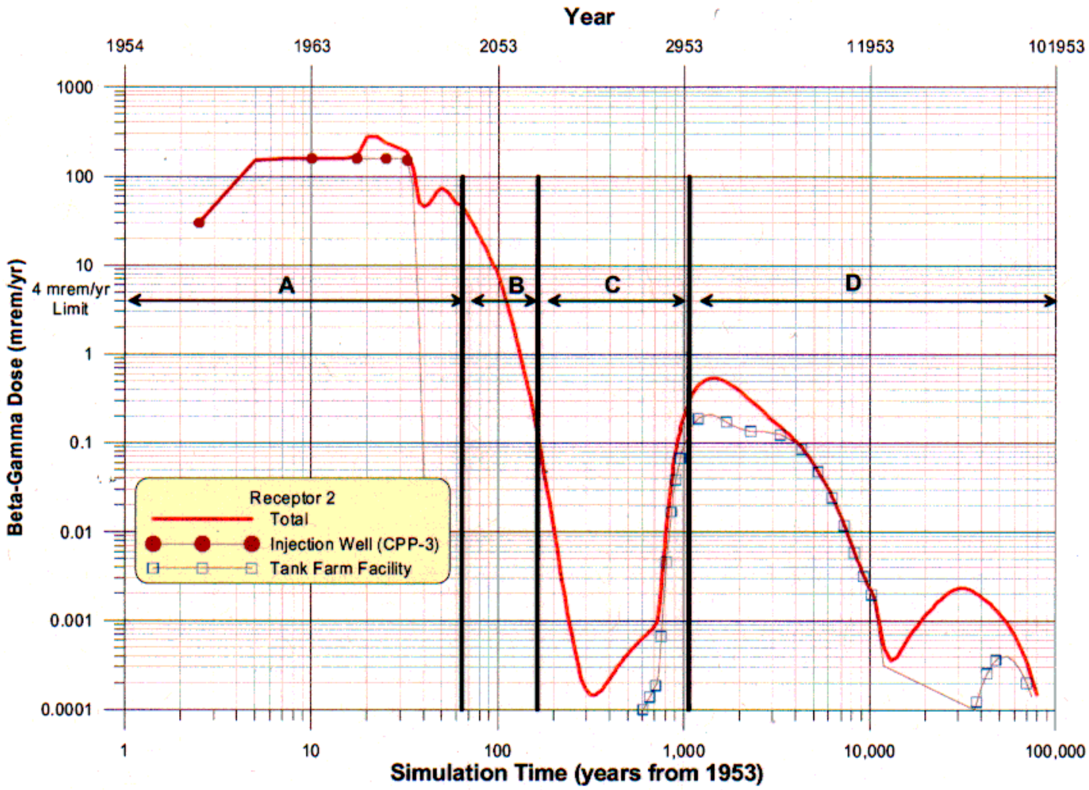

Figure 3-20. Committed dose equivalent from beta-gamma-emitting radionuclides as a function of time at Receptor 2.

3.7 Comparison of I-129 Field Data with Model Results

The ICDF landfill is an engineered landfill with no projected significant contribution to groundwater concentrations or doses within the next 1,000 years. In particular, the ICDF has no contribution to the aquifer concentrations or doses during the institutional control period from the years 2018 until 2118. However, the predicted peak beta-gamma dose from I-129 from the INTEC disposal well is a good example of the conservatism of the modeling. Based on recent aquifer sampling, the present I-129 concentrations in the aquifer from past disposals to the disposal well do not appear to be a compliance issue. The dose from the I-129 was above the MCL in the past but extensive sampling by DOE-ID indicates that currently the maximum I-129 concentrations are approximately equal to the MCL (1 pCi/L) and the concentrations are decreasing. Yet, in Section 3.6 the predicted beta-gamma dose is 69 mrem/yr or more than 17 times the 4-mrem/yr limit. This is an artificially high predicted dose that results from conservative assumptions in the model.

The remainder of this section presents aquifer field data for I-129 concentrations and addresses overly conservative assumptions used in the modeling of the INTEC disposal well contribution to the dose. This discussion allows a comparison of predicted I-129 concentrations to summer 2001 field data to verify the model over predictions.

3.7.1 Summary of the Field Data I-129 Concentrations in the Aquifer

Conservative assumptions have been used in past modeling efforts, in particular the INTEC Comprehensive RI/BRA (DOE-ID 1997). Based on that modeling, it was predicted that concentrations of I-129 greater than the 1 pCi/L MCL would persist in the aquifer. As a result of those predictions, DOE-ID has installed new wells in the aquifer downgradient of INTEC and have made aquifer monitoring of I-129 a primary objective. The source of the I-129 is primarily the INTEC disposal well that was closed in 1984 and residual I-129 in the vadose zone from time periods up to 1986 where the wastewater was disposed of directly to the deep vadose zone. The I-129 in the aquifer has been moving downgradient and dispersing since that time. An aquifer sampling campaign during the summer of 2001 was used to characterize the I-129 in the aquifer from the disposal well.

Validated I-129 aquifer sampling results from the summer of 2001 have been documented (DOE-ID 2002e) and those results are presented here in Figure 3-21 and Table 3-9. As can be seen, based on extensive aquifer sampling, the primary plume location is around CFA and the maximum concentration observed is about 1 pCi/L, which is the MCL for I-129.

3.7.2 Conservative Modeling Assumptions

By comparing the summer 2001 I-129 field data and the simulations for the ICDF CA, the level of conservatism in the ICDF CA aquifer modeling of the INTEC disposal well can be evaluated. This section contains a discussion of the model conservatism and presents the predicted I-129 concentrations in the aquifer, in year 2001, for the series of receptors in the aquifer shown in Figure 3-1.

As per the CA guidance, contributions from the INTEC facilities have not been remodeled for the ICDF evaluation, but rather the past modeling was used along with its conservatisms and the conservatisms used for the ICDF PA modeling. In the case of I-129 simulations from the INTEC disposal well, these conservative assumptions have combined to result in very conservative estimates of I-129 concentrations and resulting beta-gamma dose downgradient of the INTEC facility. As shown in Section 3.6.3, this prediction results in a significant noncompliance for the beta-gamma dose during the institutional control period. The following are the most probable conservative assumptions that lead to the conservative I-129 concentrations:

- Conservative estimates of the I-129 inventory to the INTEC disposal well.
- The GWSCREEN simulation conservatively placed contaminants into the aquifer by neglecting the influence of the mixing of water in the disposal well. A reevaluation of the water flux in the aquifer and the flux of water to the disposal well results in a conservative prediction by a factor of three.
- Heterogeneity in the aquifer resulting in more spreading of the plume than was simulated.
- Nonuniform water fluxes in the aquifer that cannot be simulated in GWSCREEN.
- Variable thickness of the aquifer that could result in mixing through an aquifer depth that is significantly larger than the modeled aquifer thickness.

The INTEC OU 3-13 Comprehensive RI/BRA modeling for the disposal well will be updated based on the aquifer field sampling results shown in Section 3.7.1, current, and future sampling. However, it was not a part of the scope of this ICDF CA. The field results and the ICDF CA modeling results are compared and discussed below.

Shown in Figure 3-22 and Table 3-10 are the ICDF landfill CA model-predicted I-129 concentrations in year 2001 as a function of distance downgradient from INTEC. The predicted peak concentration is about

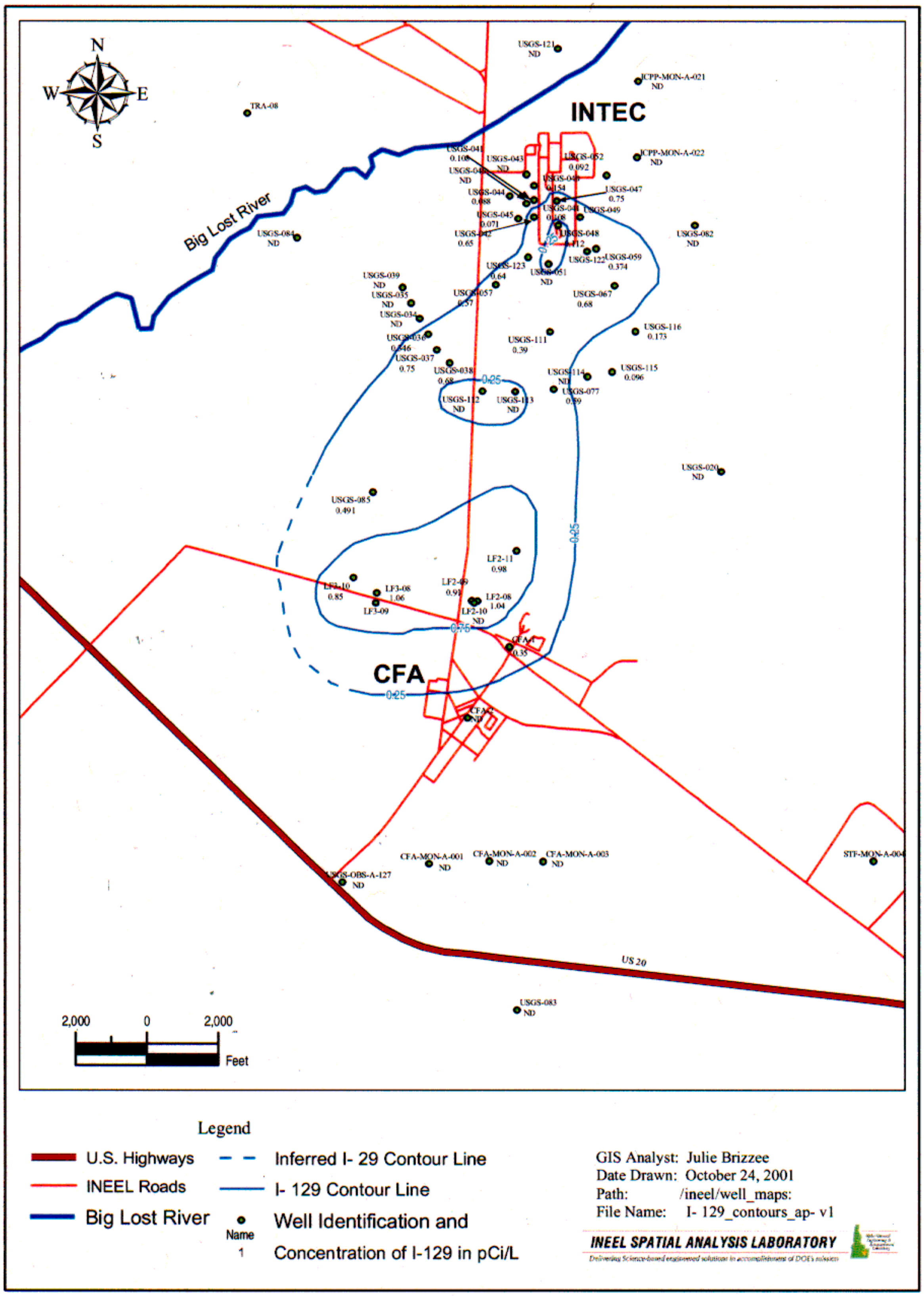

Figure 3-21. Distribution of I-129 in the SRPA in 2001.

Table 3-9. Sorted summary of the summer 2001 sampling results for iodine-129 in the SRPA.[a]

Well	QA/QC	pCi/L	+/-	Qualifier[b]	Well	QA/QC	pCi/L	+/-	Qualifier[b]
LF 3-8	Dup	**1.06**	0.19		CFA-1606		0.098	0.053	
LF 2-8		**1.04**	0.18		USGS-115		0.096	0.029	
LF 2-11		0.98	0.17		USGS-52		0.092	0.052	U
LF 2-8[c]		0.92	0.17		USGS-44		0.088	0.049	J
LF 2-9		0.91	0.16		USGS-51		0.076	0.053	U
LF 3-8		0.91	0.16		CFA-2		0.072	0.05	U
LF 3-10		0.85	0.15		USGS-45		0.071	0.049	U
USGS-37		0.75	0.14		USGS-20		0.066	0.023	UJ
USGS-47		0.75	0.13		USGS-43		0.065	0.049	U
USGS-38		0.68	0.12		USGS-112		0.06	0.05	U
USGS-67		0.68	0.12		USGS-82		0.059	0.026	U
USGS-42		0.65	0.13		USGS-34		0.055	0.023	UJ
USGS-123		0.64	0.12		USGS-46		0.052	0.047	U
USGS-37	Dup	0.61	0.12		LF 2-10		0.041	0.047	U
USGS-77		0.59	0.11		ICPP-MON-A022		0.028	0.023	U
USGS-57		0.57	0.11		ICPP-MON-A021		0.009	0.023	U
USGS-85		0.491	0.09		RINSE		0.003	0.028	U
USGS-111		0.39	0.088		USGS-84		-0.005	0.017	U
USGS-59		0.374	0.084		USGS-121		-0.008	0.045	U
CFA-1		0.352	0.083		USGS-113		-0.009	0.05	U
USGS-36		0.346	0.066		USGS-39		-0.011	0.017	U
USGS-116		0.173	0.038		USGS-127		-0.016	0.042	U
USGS-114		0.163	0.036		USGS-35		-0.021	0.048	U
USGS-40		0.154	0.036		CFA-MON-A-002		-0.024	0.046	U
CFA-1606	Dup	0.112	0.056		CFA-MON-A-001		-0.045	0.044	U
USGS-48		0.112	0.053	J	CFA-MON-A-003		-0.045	0.044	U
USGS-41		0.108	0.051	J	USGS-83		-0.057	0.05	U

a. Bold indicates a value equal or greater than the MCL; MCL = 1 pCi/L.

b. “U” indicates that an analyte was not detected. “J” indicates an estimated value. “UJ” indicates that the result is not detectable at the reported value but the reported value is only an estimate.

c. Resampled in August 2001.

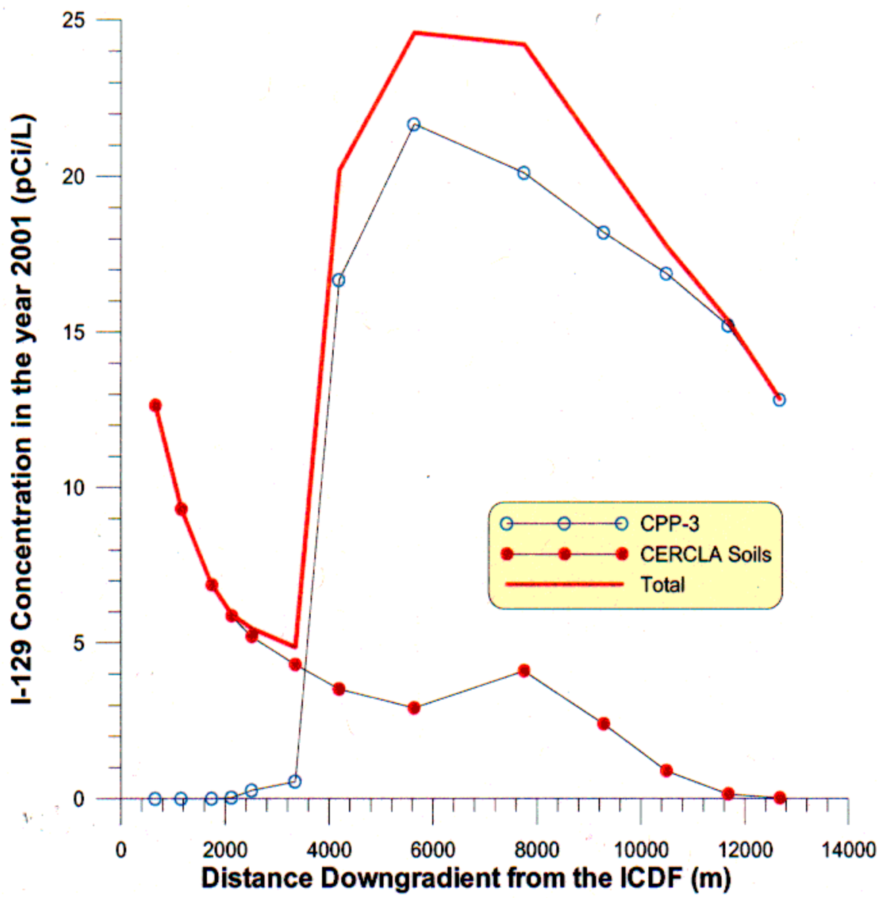

Figure 3-22. Year 2001 predicted I-129 concentrations as a function of distance downgradient of INTEC.

Table 3-10. Year 2001 predicted I-129 concentrations as a function of distance downgradient of INTEC and the contribution from the primary INTEC sources.

Distance from ICDF (m)	Concentration (pCi/L) and Primary Sources					Total (pCi/L)
	CPP-3	CPP-659	TFF	TF-Soils	Bin Sets	
639	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
662	2.56E-08	0.00E+00	0.00E+00	1.26E+01	0.00E+00	1.26E+01
1158	1.83E-06	0.00E+00	0.00E+00	9.30E+00	0.00E+00	9.30E+00
1745	1.76E-03	0.00E+00	0.00E+00	6.86E+00	0.00E+00	6.86E+00
2128	3.59E-02	0.00E+00	0.00E+00	5.86E+00	0.00E+00	5.89E+00
2513	2.66E-01	0.00E+00	0.00E+00	5.19E+00	0.00E+00	5.46E+00
3350	5.49E-01	0.00E+00	0.00E+00	4.30E+00	0.00E+00	4.85E+00
4190	1.67E+01	0.00E+00	0.00E+00	3.51E+00	0.00E+00	2.02E+01
5635	2.17E+01	0.00E+00	0.00E+00	2.91E+00	0.00E+00	2.46E+01
7750	2.01E+01	0.00E+00	0.00E+00	4.10E+00	0.00E+00	2.42E+01
9284	1.82E+01	0.00E+00	0.00E+00	2.39E+00	0.00E+00	2.06E+01
10494	1.69E+01	0.00E+00	0.00E+00	8.88E-01	0.00E+00	1.78E+01
11682	1.52E+01	0.00E+00	0.00E+00	1.43E-01	0.00E+00	1.53E+01
12677	1.28E+01	0.00E+00	0.00E+00	1.95E-02	0.00E+00	1.28E+01

18 pCi/L and it occurs to the south of the CFA. Comparing this with the I-129 field data shown in Figure 3-21 and Table 3-9 above, the model predicts that the plume has moved further than shown in the field data and the predicted maximum concentration is about 18 times that found in the aquifer. Since the aquifer monitoring is not exhaustive, it is possible that there is I-129 at somewhat higher concentrations. A reasonable assumption is that the modeling is an order of magnitude conservative.

4. SENSITIVITY AND UNCERTAINTY ANALYSIS

The primary purpose of this sensitivity and uncertainty analysis is to support the determination that the results of the CA lead to a conclusion that there is a reasonable expectation of meeting the performance objectives. As with the performance assessment, the sensitivity/uncertainty analysis will calculate the maximum dose beyond the 1,000-year period used for the compliance period, out to year 100,000. These calculations are presented in order to increase the understanding of the models used, but are not used for determining compliance with the dose limit and constraint. The results calculated for many thousands of years must be evaluated with caution. However, the results are useful in understanding the potential for significant problems far in the future.

To facilitate interpretation of the results of the CA, a limited sensitivity analysis was carried out. The ICDF Landfill PA (DOE-ID 2003a) sensitivity and uncertainty analyses contained an extensive assessment of parameters and assumptions and is briefly discussed below. Sensitivity and uncertainty analyses are presented in that report.

The following sensitivity analyses were performed for the ICDF landfill PA model:

- Sensitivity of I-129 concentrations to the sorption coefficient in waste and interbed material
- Sensitivity of I-129 concentration and dose to cover integrity assumptions.

A parametric uncertainty analysis was performed for the ICDF landfill PA modeling. The parametric uncertainty analysis incorporated the following:

- Background percolation rates outside the ICDF landfill engineered cover
- ICDF landfill percolation rates through the engineered cover
- Dispersivity in the aquifer
- Dispersivity in the vadose zone
- Darcy velocity in the aquifer
- Sorption coefficients for the contaminants of potential concern
- Infiltration-reducing effective lifetime of the engineered cover over the ICDF landfill.

Since the radionuclide inventories assumed for the ICDF landfill CA sources (outside the ICDF landfill) are all considered to be conservative, the results presented in Section 3.5 are bounding with respect to radionuclide inventories. Since the predicted doses are relatively low with the conservative source term used in the base case, additional sensitivity analysis on the overall source term of ICDF landfill sources are not warranted at this time.

The limited sensitivity analyses carried out for this ICDF landfill CA are presented and summarized in the following sections:

- Section 4.1 contains the simulation of all-pathways dose results assuming that the infiltration-reducing cover on the ICDF landfill begins to fail in 100 years and fails over the next 20 years instead of the design life of 1,000 years.

- Section 4.2 contains the simulation results assuming that the CERCLA soils K_d for plutonium decreases from 220 mL/g to 22 mL/g in the contaminated surface soils and the vadose zone interbeds. Note this does not assume that the plutonium K_d value is decreased for any of the other sites.

- Section 4.3 contains the simulation results assuming the infiltration through the ICDF landfill cover is an order of magnitude higher than the base case value of 0.01 cm/yr (0.004 in./yr) during the 0- to 500-year timeframe.

- Section 4.4 contains a discussion of the influence on predicted dose assuming that the contaminants in the INTEC are directly upgradient of the ICDF landfill plume.

- Section 4.5 contains a summary of the limited sensitivity results with the CA base case results.

4.1 ICDF Cover Fails in 100 Years

The ICDF landfill CA all-pathways dose base case as presented in Section 3.5 assumes the ICDF landfill cover restricts infiltration to 0.01 cm/yr (0.004 in./yr) as designed and performs at this level for 500 years. For this sensitivity analysis, it is assumed that the cover begins to fail in 100 years rather than 500 years and it fails over 20 years rather than 500 years. The all-pathways dose results are shown in Figures 4-1 through 4-3 and in Table 4-1. As with the Section 3.5 results, Table 4-1 is divided into three timeframes: institutional control (until year 2118), compliance period (year 2118 to 3018), and postcompliance period (year 3018 to 100,000). The compliance period of 3053 is used because the model was built to output a solution at that time period.

As discussed in Section 3.5, the ICDF landfill is not upgradient of Receptor 2, so this sensitivity run does not affect the predicted doses at Receptor 2. However, at later times it does have an effect on the predicted all-pathways doses at Receptors 1 and 3. In particular, Receptor 1 is downgradient from the center of the ICDF landfill and therefore will be significantly influenced. The resulting all-pathways doses are summarized below for three time periods:

- Institutional control period (2018–2118)—The only receptor for this time period is Receptor 4 at the INEEL boundary. The peak all-pathways dose from the ICDF landfill is the same as the base case (7.8 mrem/yr) because radionuclides released from the ICDF landfill do not reach the aquifer during this timeframe, much less travel to the INEEL boundary. No all-pathways dose figure is included because it is the same as Figure 3-8.

- Compliance control period (2118–3018)—The doses predicted at Receptors 1, 2, and 3 are 3.3, 8.1, and 2.4 mrem/yr, respectively. During this period, the ICDF landfill cover is assumed to have degraded and provides no infiltration barrier. Therefore, the doses for Receptors 1 and 3 are different from the base case because, for the base case, the cover remains intact for 500 years and then gradually fails over the next 500 years. At Receptor 3, the difference is only discernable at three significant digits. However, at Receptor 1, the difference is significant (3.3 versus 0.4 mrem/yr).

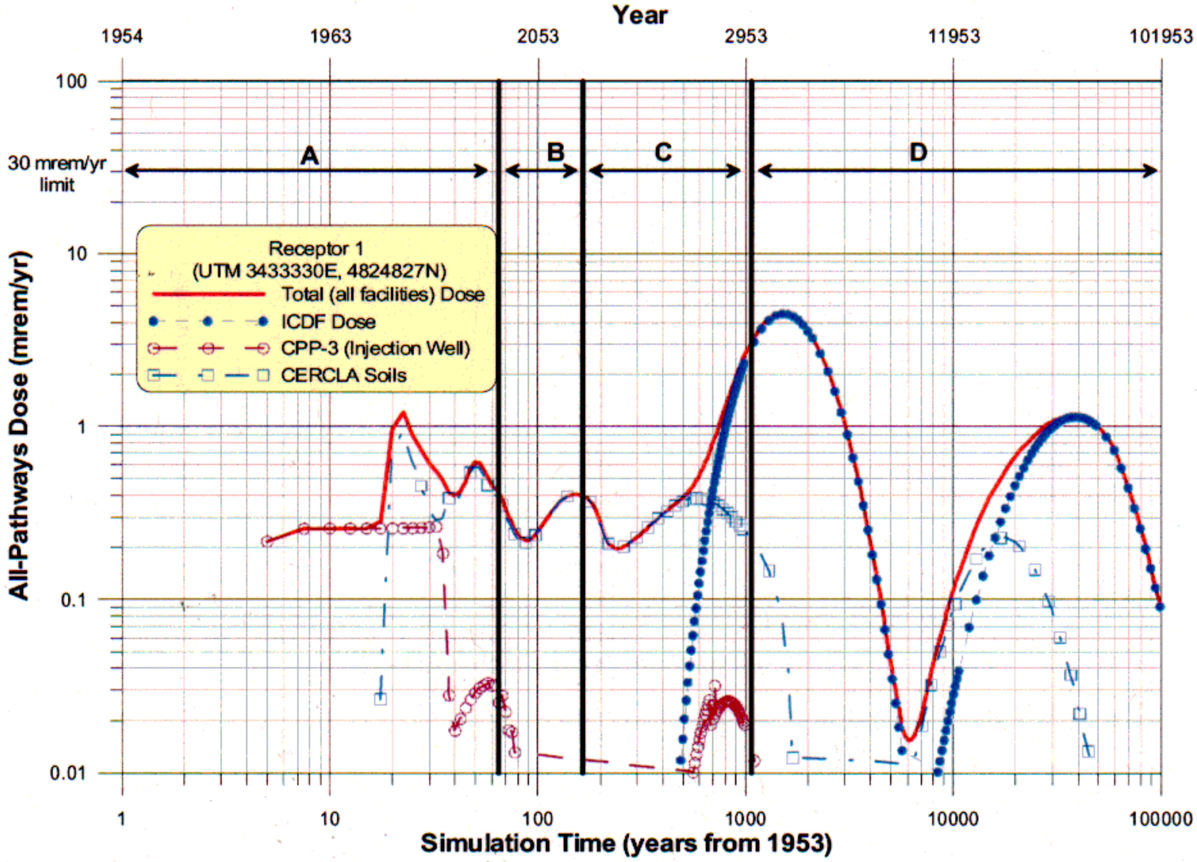

Figure 4-1. Receptor 1 all-pathways dose estimate changing the ICDF landfill cover failure time to 100 years.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

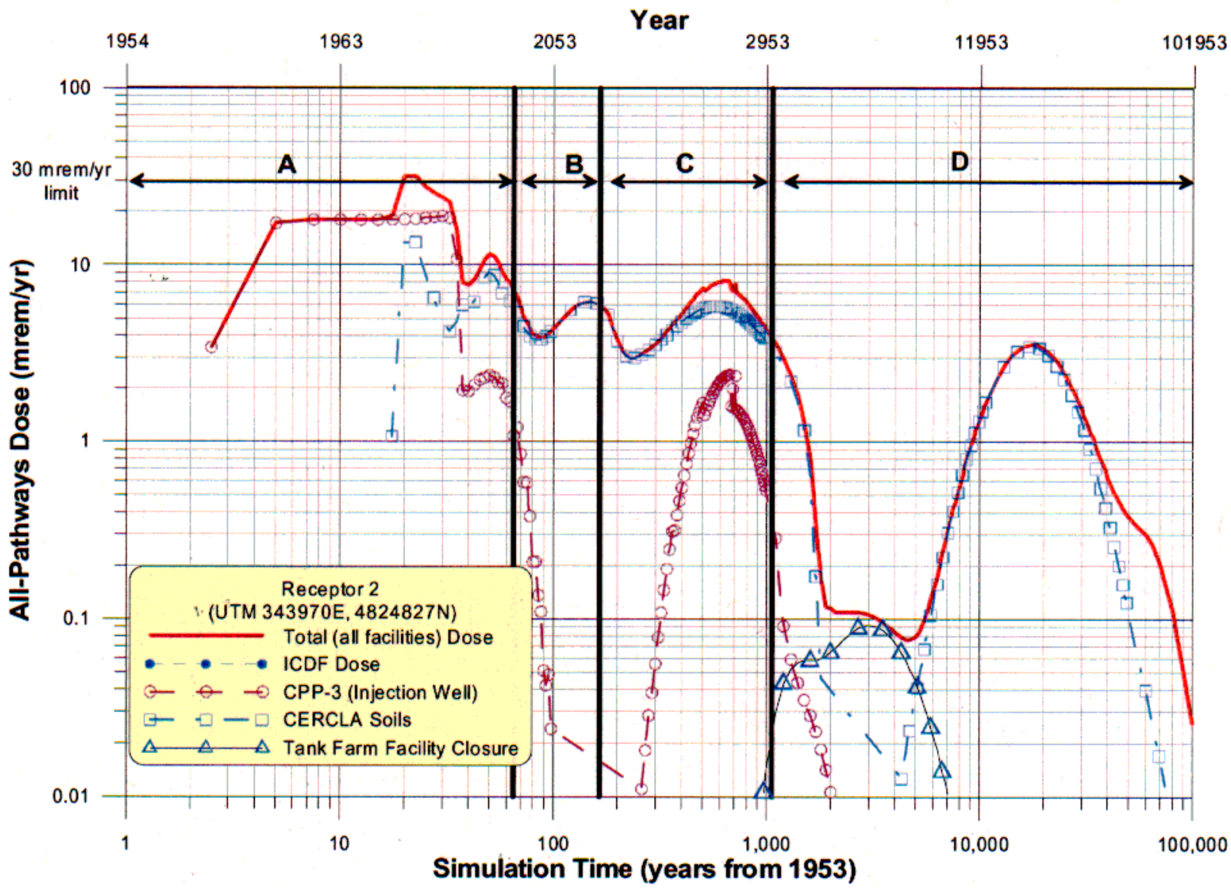

Figure 4-2. Receptor 2 all-pathways dose estimate changing the ICDF landfill cover failure time to 100 years.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

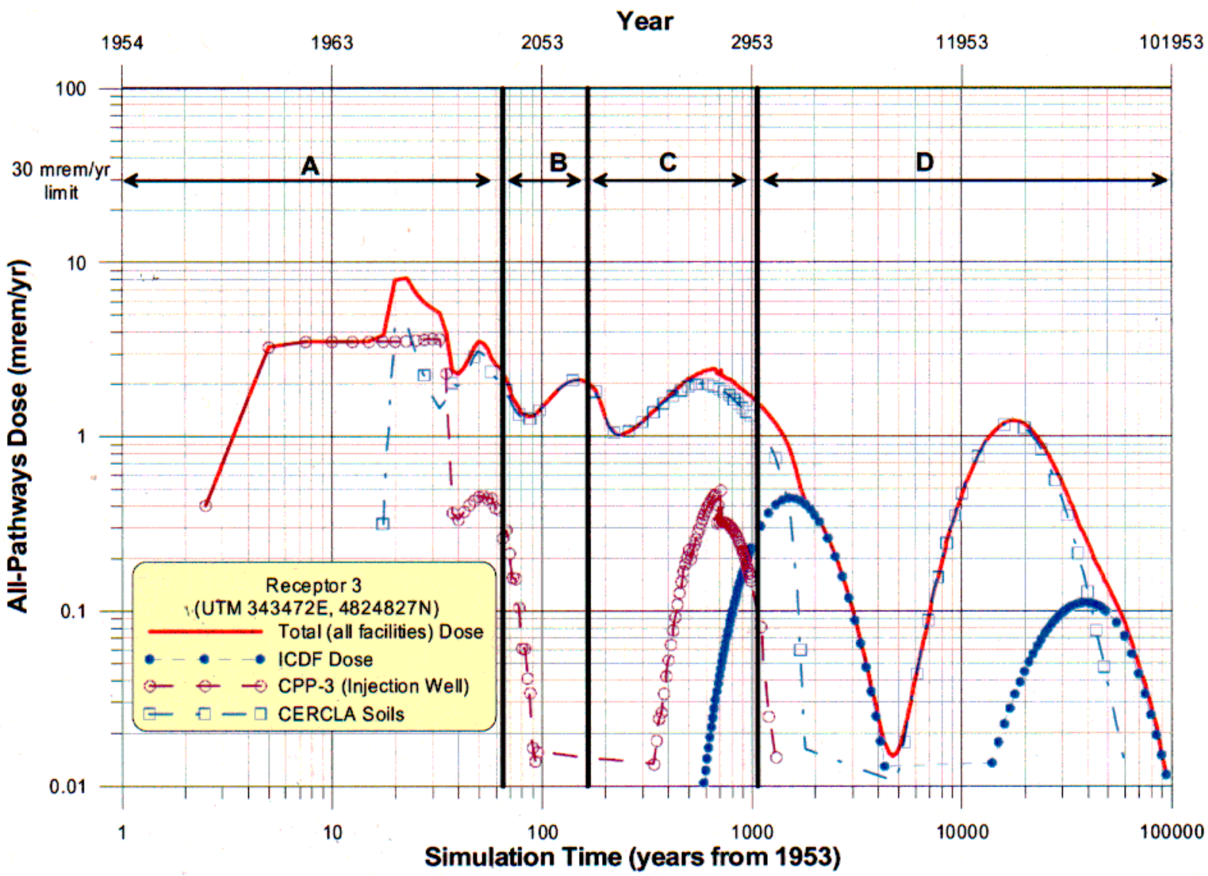

Figure 4-3. Receptor 3 all-pathways dose estimate changing the ICDF landfill cover failure time to 100 years.

Note: The letters at the top of the graph refer to the following time periods: A= pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

Table 4-1. Summary of the all-pathways dose analysis for the ICDF landfill CA with the ICDF landfill cover failing after 100 years.

Timeframe		Receptor 1	Receptor 2	Receptor 3	Receptor 4
2018–2118	Year of maximum all-pathways dose				2018
	Maximum all-pathways dose (mrem/yr)				7.80
	Percent of dose from each source at time of maximum dose:				
	ICDF				0.00%
	INTEC injection well (CPP-3)				88.03%
	CPP-601				0.00%
	CPP-603				0.00%
	WCF (CPP-633)				0.00%
	NWCF (CPP-659)				0.00%
	Tank farm closure				0.00%
	CERCLA soils				11.97%
	Tank farm bin sets				0.00%
	Radionuclide contributions at time of maximum dose:				
	Am-241				0.00%
	C-14				0.00%
	I-129				100.00%
	Np-237				0.00%
	Pu-239				0.00%
	Pu-240				0.00%
	Tc-99				0.00%
	U-234				0.00%
	U-238				0.00%
Timeframe		Receptor 1	Receptor 2	Receptor 3	
2118–3018	Year of maximum all-pathways dose	3018	2583	2613	
	Maximum all-pathways dose (mrem/yr)	3.34	8.12	2.43	
	Percent of dose from each source at time of maximum dose				
	ICDF	93.24%	0.00%	1.13%	
	INTEC injection well (CPP-3)	0.35%	28.43%	18.80%	
	CPP-601	0.00%	0.00%	0.00%	
	CPP-603	0.00%	0.00%	0.00%	
	WCF (CPP-633)	0.00%	0.00%	0.00%	
	NWCF (CPP-659)	0.00%	0.00%	0.00%	
	Tank farm closure	0.00%	0.00%	0.00%	
	CERCLA soils	6.41%	71.57%	80.07%	
	Tank farm bin sets	0.00%	0.00%	0.00%	

Table 4-1. (continued).

Timeframe		Receptor 1	Receptor 2	Receptor 3
	Radionuclide contributions at time of maximum dose:			
	Am-241	0.00%	0.03%	0.01%
	C-14	0.00%	0.00%	0.00%
	I-129	93.23%	0.00%	1.13%
	Np-237	4.68%	54.05%	60.69%
	Pu-239	0.31%	25.11%	16.62%
	Pu-240	0.04%	3.29%	2.18%
	Tc-99	0.01%	0.00%	0.00%
	U-234	0.93%	9.40%	10.38%
	U-238	0.81%	8.12%	8.99%
Timeframe		Receptor 1	Receptor 2	Receptor 3
3018–100,000	Year of maximum all-pathways dose	3453	19,953	3153
	Maximum all-pathways dose (mrem/yr)	4.59	3.56	1.32
	Percent of dose from each source at time of maximum dose:			
	ICDF	98.29%	0.00%	27.65%
	INTEC injection well (CPP-3)	0.01%	0.00%	1.87%
	CPP-601	0.00%	0.00%	0.05%
	CPP-603	0.00%	0.00%	0.00%
	WCF (CPP-633)	0.00%	0.00%	0.00%
	NWCF (CPP-659)	0.00%	0.15%	0.00%
	Tank farm closure	0.00%	0.00%	0.02%
	CERCLA soils	1.70%	97.71%	70.41%
	Tank farm bin sets	0.00%	2.14%	0.00%
	Radionuclide contributions at time of maximum dose:			
	Am-241	0.01%	0.00%	0.34%
	C-14	0.00%	0.00%	0.01%
	I-129	97.93%	0.00%	27.70%
	Np-237	1.11%	2.07%	50.73%
	Pu-239	0.01%	83.82%	1.36%
	Pu-240	0.00%	13.89%	0.17%
	Tc-99	0.36%	0.00%	0.01%
	U-234	0.31%	0.21%	10.55%
	U-238	0.27%	0.00%	9.13%

- Postcompliance period (3018–100,000)—The dose predicted at Receptors 1, 2, and 3 are 4.6, 3.6, and 1.3 mrem/yr, respectively. As with the base case, the cover is assumed to be compromised at this point, failing in the year 2118, and provide no infiltration barrier. For Receptor 1, the predicted peak all-pathways dose is basically the same for the sensitivity and base case simulations, but the times to the peak concentrations are different. For Receptor 2, the results are unchanged because the ICDF landfill does not influence this receptor location. For Receptor 3, having the cover fail in 100 years instead of 500 years results in the predicted peak all-pathways dose increasing from 1.2 to 1.3 mrem/yr and the year of the peak being moved forward.

The failure of the ICDF landfill cover in 100 years versus 500 years does not significantly change the predicted peak all-pathways doses but does move the peak dose at Receptors 1 and 3 forward in time. In any case, there is no predicted dose in the compliance control period that approaches the CA compliance dose of 100 mrem/yr or the required options analysis dose constraint of 30 mrem/yr.

4.2 CERCLA Soils K_d for Pu Reduced to 22 mL/g

As explained in Section 3.5, the INTEC CERCLA soils are a primary contributor to the ICDF landfill CA dose. Two of the primary contaminants of concern are Pu-239 and Pu-240. In the INTEC comprehensive RI/FS (DOE-ID 1997) the plutonium K_d for soils was conservatively assumed to be 22 mL/g and a sensitivity simulation was run with the K_d increased to 220 mL/g. Since there is much more evidence to support a soils plutonium K_d of 220 mL/g than 22 mL/g, the value of 220 mL/g was used for the base case simulations. For completeness, this sensitivity simulation is provided to show the influence on the simulations if the CERCLA soils are simulated with a K_d value of 22 mL/g. Note that the K_d value was only changed for the surface soils and interbeds in the CERCLA soils source, not for any of the other sources.

The results of this simulation are shown in Figures 4-4 through 4-6 and Table 4-2. The resulting all-pathways doses are summarized below for these time periods:

- Institutional control period (2018–2118)—The only receptor for this time period is Receptor 4 at the INEEL boundary. The peak all-pathways dose from INTEC facilities is the same as the base case (7.8 mrem/yr) because radionuclides released from the CERCLA soils landfill do not reach the aquifer during this timeframe, much less travel to the INEEL boundary. No all-pathways dose figure is included because it is the same as Figure 3-8.

- Compliance period (2118–3018)—The doses predicted at Receptors 1, 2, and 3 are 2.4, 37, and 12 mrem/yr, respectively. These doses are substantially higher than the base case and reflect higher doses due to plutonium isotopes.

- Postcompliance period (3018–100,000)—The doses predicted at Receptors 1, 2, and 3 are 8.9, 70, and 24 mrem/yr, respectively. These doses are substantially higher than the base case and reflect higher doses due to plutonium isotopes. The CERCLA soil source accounts for half the dose at Receptor 1. Doses are also higher at Receptors 2 and 3. At Receptor 2, the peak occurs in year 3753, which is much sooner than the base case peak in year 19,953. Similarly, for Receptor 3, the peak time is shortened from year 19,953 to year 3753.

Although a plutonium K_d of 22 mL/g would significantly increase the aquifer all-pathways dose, the receptor locations where the dose is significantly higher have a small contribution from the ICDF landfill.

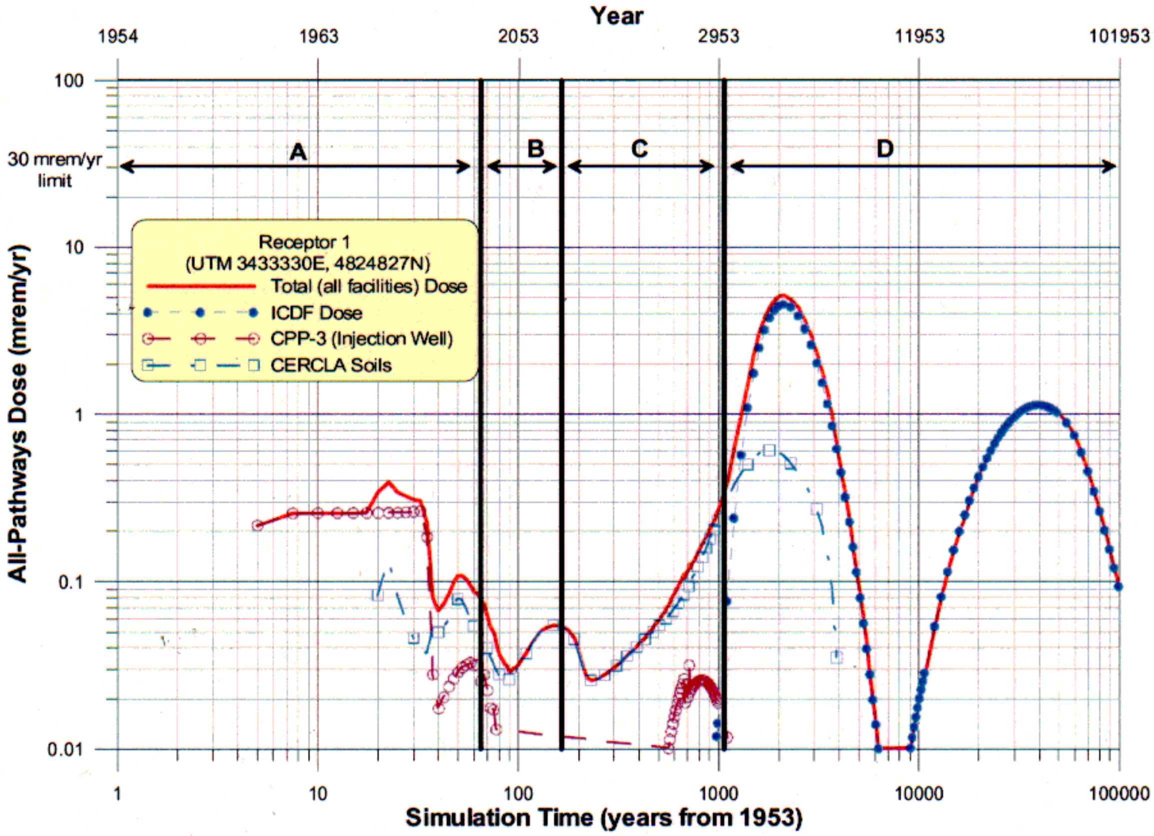

Figure 4-4. Receptor 1 all-pathways dose estimate assuming the CERCLA soils Pu K_d is 22 instead of 220 mL/g.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

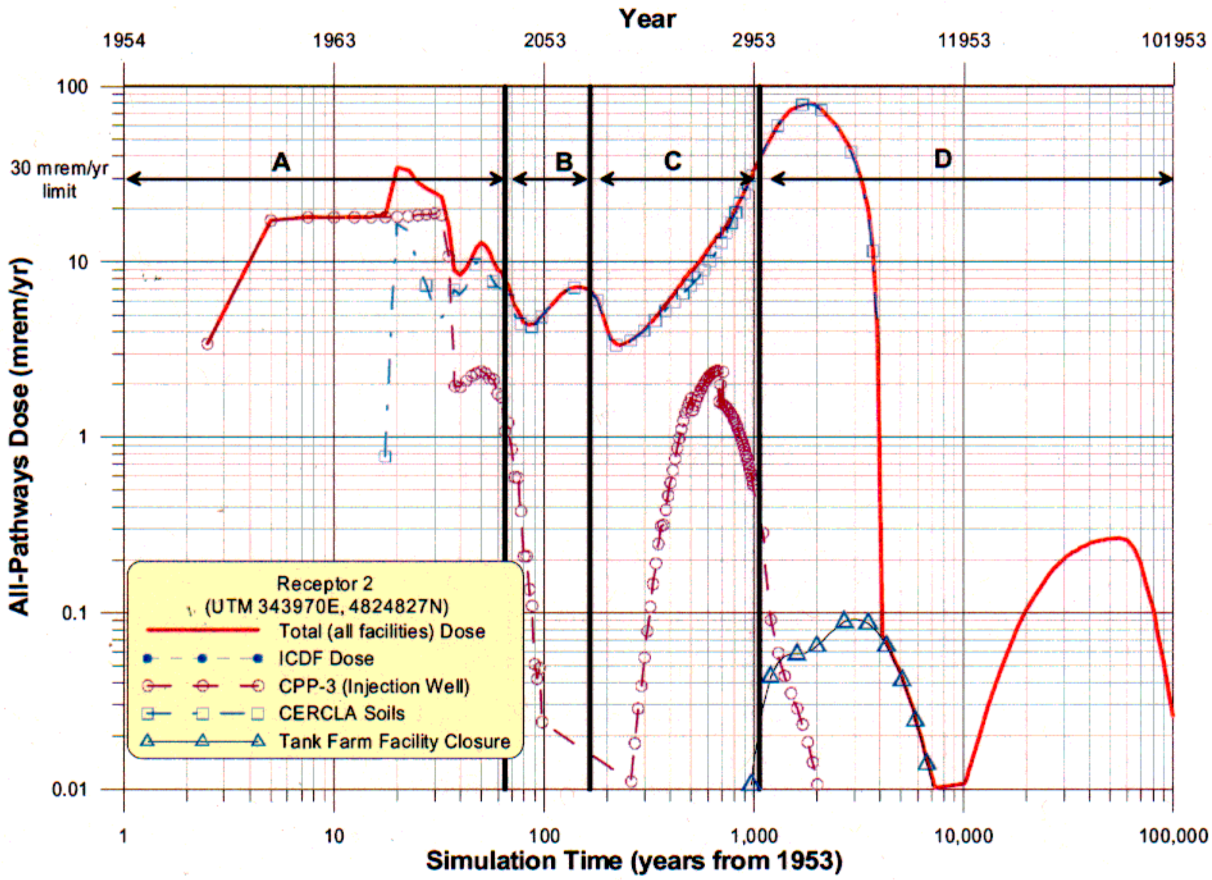

Figure 4-5. Receptor 2 all-pathways dose estimate assuming the CERCLA soils Pu K_d is 22 instead of 220 mL/g.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

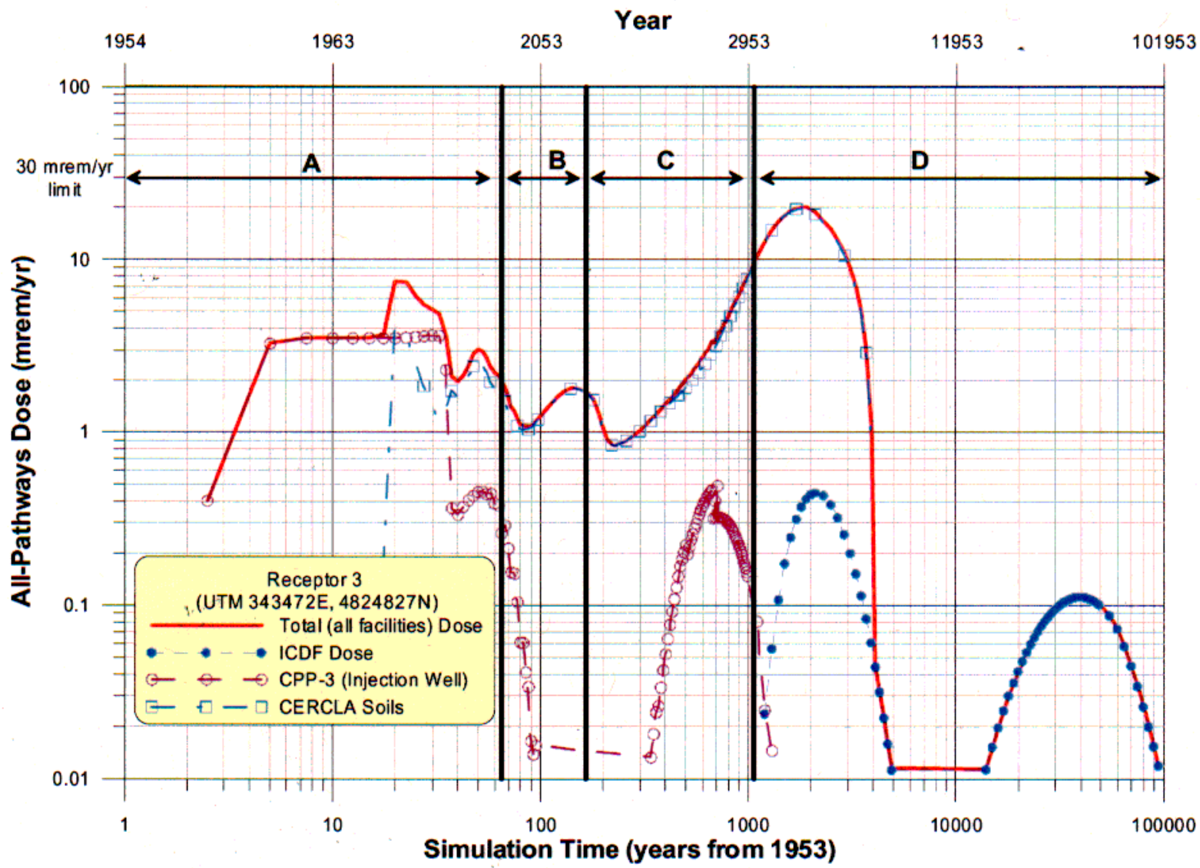

Figure 4-6. Receptor 3 all-pathways dose estimate assuming the CERCLA soils Pu K_d is 22 instead of 220 mL/g.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

Table 4-2. Summary of the all-pathways dose analysis for the ICDF landfill CA using a plutonium K_d value of 22 mL/g for the CERCLA soils source.

Timeframe			Receptor 4	
2018–2118	Year of maximum all-pathways dose		2018	
	Maximum all-pathways dose (mrem/yr)		7.8E+00	
	Percent of dose from each source at time of maximum dose:			
	ICDF		0.00%	
	INTEC injection well (CPP-3)		88.03%	
	CPP-601		0.00%	
	CPP-603		0.00%	
	WCF (CPP-633)		0.00%	
	NWCF (CPP-659)		0.00%	
	Tank farm closure		0.00%	
	CERCLA soils		11.97%	
	Tank farm bin sets		0.00%	
	Radionuclide contributions at time of maximum dose:			
	Am-241		0.00%	
	C-14		0.00%	
	I-129		100.00%	
	Np-237		0.00%	
	Pu-239		0.00%	
	Pu-240		0.00%	
	Tc-99		0.00%	
	U-234		0.00%	
	U-238		0.00%	
Timeframe		Receptor 1	Receptor 2	Receptor 3
2118–3018	Year of maximum all-pathways dose	3018	3018	3018
	Maximum all-pathways dose (mrem/yr)	2.40	36.94	12.49
	Percent of dose from each source at time of maximum dose:			
	ICDF	3.18%	0.00%	0.06%
	INTEC injection well (CPP-3)	0.49%	0.77%	0.64%
	CPP-601	0.00%	0.01%	0.00%
	CPP-603	0.00%	0.00%	0.00%
	WCF (CPP-633)	0.00%	0.00%	0.00%
	NWCF (CPP-659)	0.00%	0.00%	0.00%
	Tank farm closure	0.00%	0.08%	0.00%
	CERCLA soils	96.33%	99.09%	99.29%
	Tank farm bin sets	0.00%	0.05%	0.00%

Table 4-2. (continued).

Timeframe		Receptor 1	Receptor 2	Receptor 3
	Radionuclide contributions at time of maximum dose:			
	Am-241	0.00%	0.12%	0.04%
	C-14	0.00%	0.03%	0.00%
	I-129	3.17%	0.10%	0.06%
	Np-237	6.51%	6.38%	6.44%
	Pu-239	54.96%	56.94%	56.96%
	Pu-240	32.93%	34.05%	34.09%
	Tc-99	0.01%	0.00%	0.00%
	U-234	1.29%	1.27%	1.28%
	U-238	1.12%	1.10%	1.11%
Timeframe		Receptor 1	Receptor 2	Receptor 3
3018–100,000	Year of maximum all-pathways dose	3953	3753	3753
	Maximum all-pathways dose (mrem/yr)	8.90	69.82	24.14
	Percent of dose from each source at time of maximum dose:			
	ICDF	49.99%	0.00%	1.54%
	INTEC injection well (CPP-3)	0.00%	0.03%	0.02%
	CPP-601	0.00%	0.02%	0.01%
	CPP-603	0.00%	0.00%	0.00%
	WCF (CPP-633)	0.00%	0.00%	0.00%
	NWCF (CPP-659)	0.00%	0.00%	0.00%
	Tank farm closure	0.00%	0.09%	0.00%
	CERCLA soils	50.01%	99.83%	98.44%
	Tank farm bin sets	0.00%	0.04%	0.00%
	Radionuclide contributions at time of maximum dose:			
	Am-241	0.00%	0.03%	0.02%
	C-14	0.00%	0.03%	0.00%
	I-129	49.11%	0.07%	1.52%
	Np-237	0.00%	0.00%	0.00%
	Pu-239	31.96%	63.44%	62.56%
	Pu-240	18.05%	36.32%	35.81%
	Tc-99	0.87%	0.05%	0.02%
	U-234	0.00%	0.04%	0.04%
	U-238	0.00%	0.03%	0.03%

4.3 Infiltration through the ICDF Landfill Cover an Order of Magnitude Higher

During the first 500 years after closure of the ICDF landfill, the engineered cover is assumed to remain intact and infiltration through the cover is estimated to be 0.01 cm/yr (0.004 in./yr). This simulation examines the sensitivity of the all-pathways dose to an order-of-magnitude increase in the infiltration rate through the cover (0.1 cm/yr) while the cover remains intact (500 years). The results are illustrated in Figures 4-7 through 4-9 and Table 4-3. The resulting all-pathways doses are summarized below for these time periods:

- Institutional control period (2018–2118)—The only receptor for this time period is Receptor 4 at the INEEL boundary. The peak all-pathways dose from the ICDF landfill is the same as the base case (7.8 mrem/yr) because radionuclides released from the ICDF landfill do not reach the aquifer during this timeframe, much less travel to the INEEL boundary. No all-pathways dose figure is included because it is the same as Figure 3-8.

- Compliance control period (2118–3018)—The peak dose of 0.4 mrem/yr at Receptor 1 increases slightly to 0.42 mrem/y as a result of the increase in the infiltration rate.

- Postcompliance period (3018–100,000)—The peak all-pathways dose actually goes down slightly at Receptor 1 (from 4.6 mrem to 4.5 mrem) because some of the I-129 in the ICDF landfill has leached out earlier due to increased infiltration rate.

4.4 All INTEC Facilities are Directly Upgradient of the ICDF Landfill

Aquifer gradients are from north to south in the vicinity of INTEC and the ICDF landfill. Since the INTEC source terms contributing in the ICDF CA are to the east of the ICDF landfill, the centerlines of the ICDF landfill and other plumes are not aligned. The sensitivity of the predicted peak dose to the direction of flow in the aquifer is evaluated by assuming that the centerline of the primary plume from the sources at INTEC moves directly to the ICDF landfill and the peak predicted doses sum without any concentration reduction from dispersion. A conservative way to estimate this dose is simply to add the ICDF all-pathways dose at Receptor 1 to all the other sources at Receptor 2. The results of this simulation are shown in Figure 4-10. The resulting all-pathways doses are summarized below for these time periods:

- Institutional control period (2018–2118)—The only receptor for this time period is Receptor 4 at the INEEL boundary. The peak all-pathways dose is the same as the base case because the ICDF has no influence on concentrations during this timeframe.

- Compliance control period (2118–3018)—The peak all-pathways dose is 8.1 mrem/yr and occurs in the year 2583 which is the same as the base case.

- Postcompliance period (3018–100,000)—The peak all-pathways dose is 4.6 mrem/yr and it occurs in year 4053. This dose is also unchanged from the base case.

The reason why the doses in this sensitivity case did not change from the base case is because each source arrives at the aquifer at a different time; therefore, their contaminant plumes do not appear to overlap each other. Thus, having the INTEC facilities directly upgradient of the ICDF landfill does not affect the overall dose from INTEC.

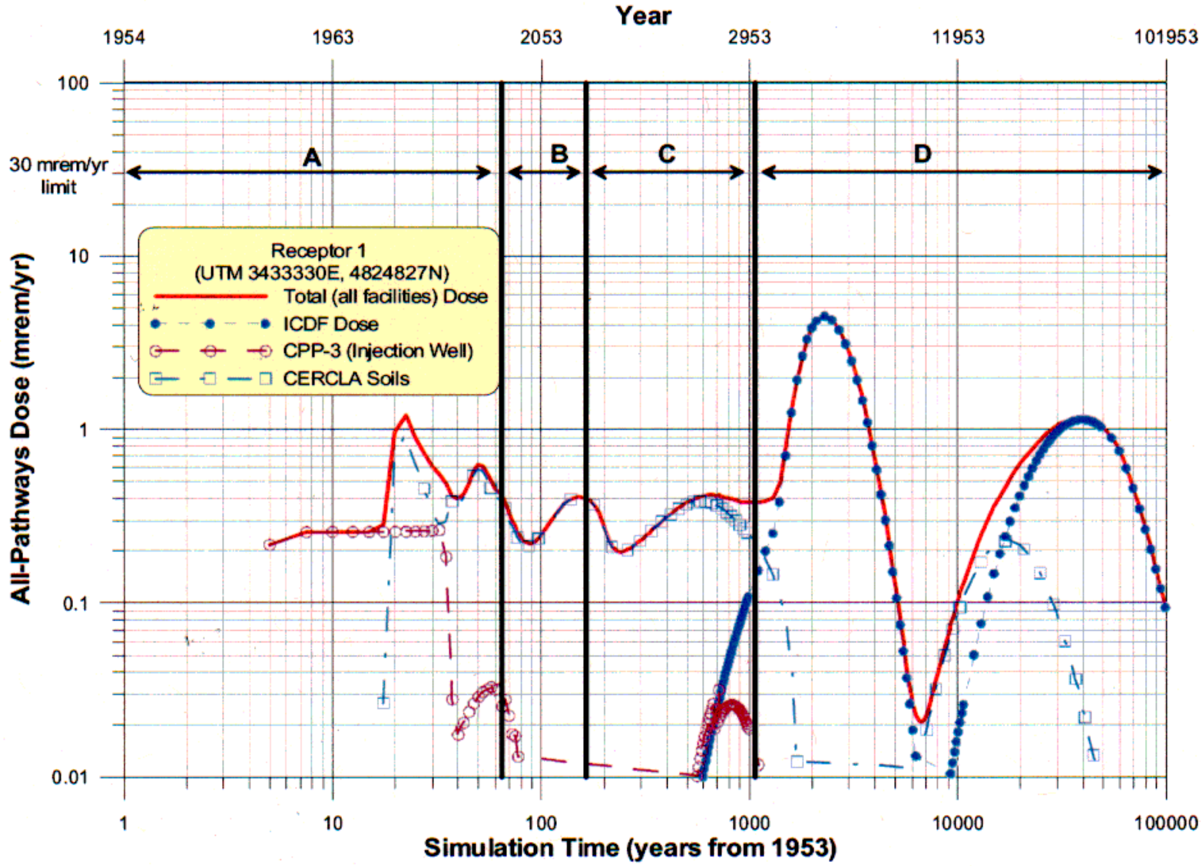

Figure 4-7. Receptor 1 all-pathways as a function of time estimate assuming a 0.1-cm/yr infiltration rate through the ICDF landfill cover.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

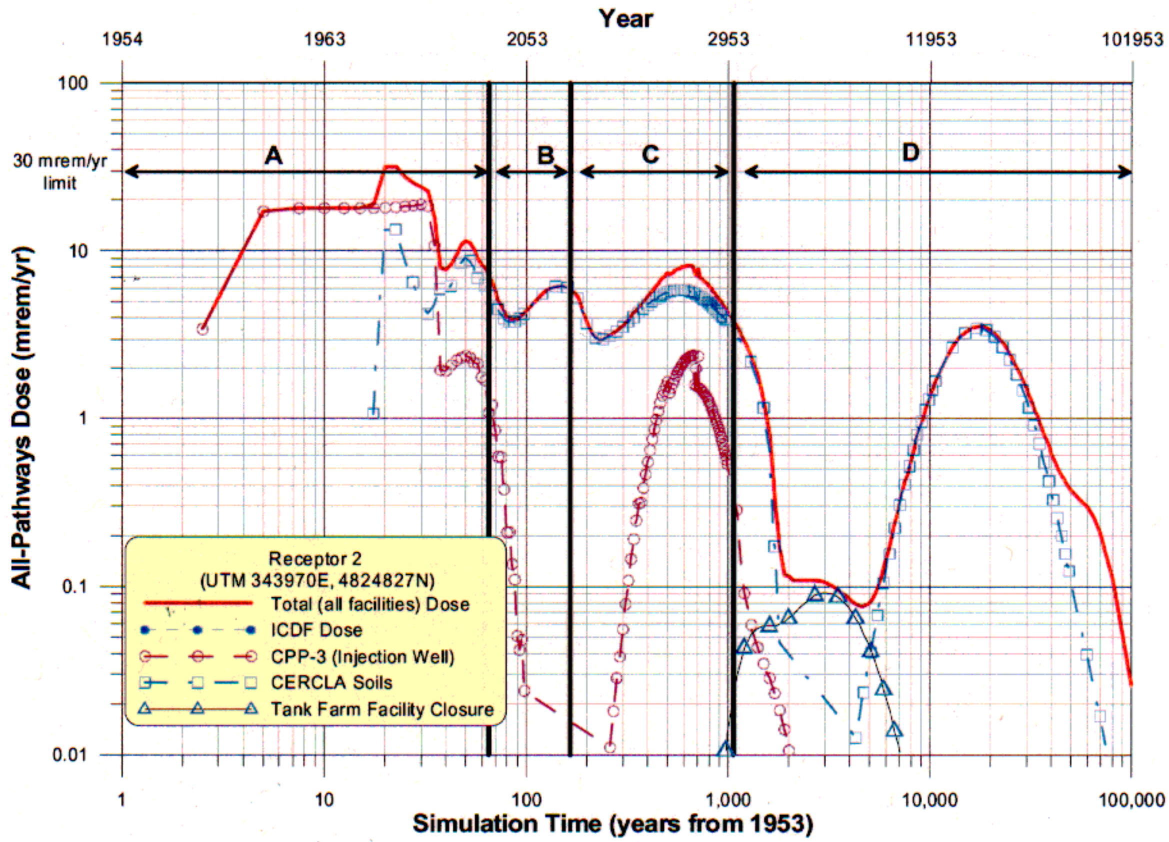

Figure 4-8. Receptor 2 all-pathways dose as a function of time assuming a 0.1-cm/yr infiltration rate through the ICDF landfill cover.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

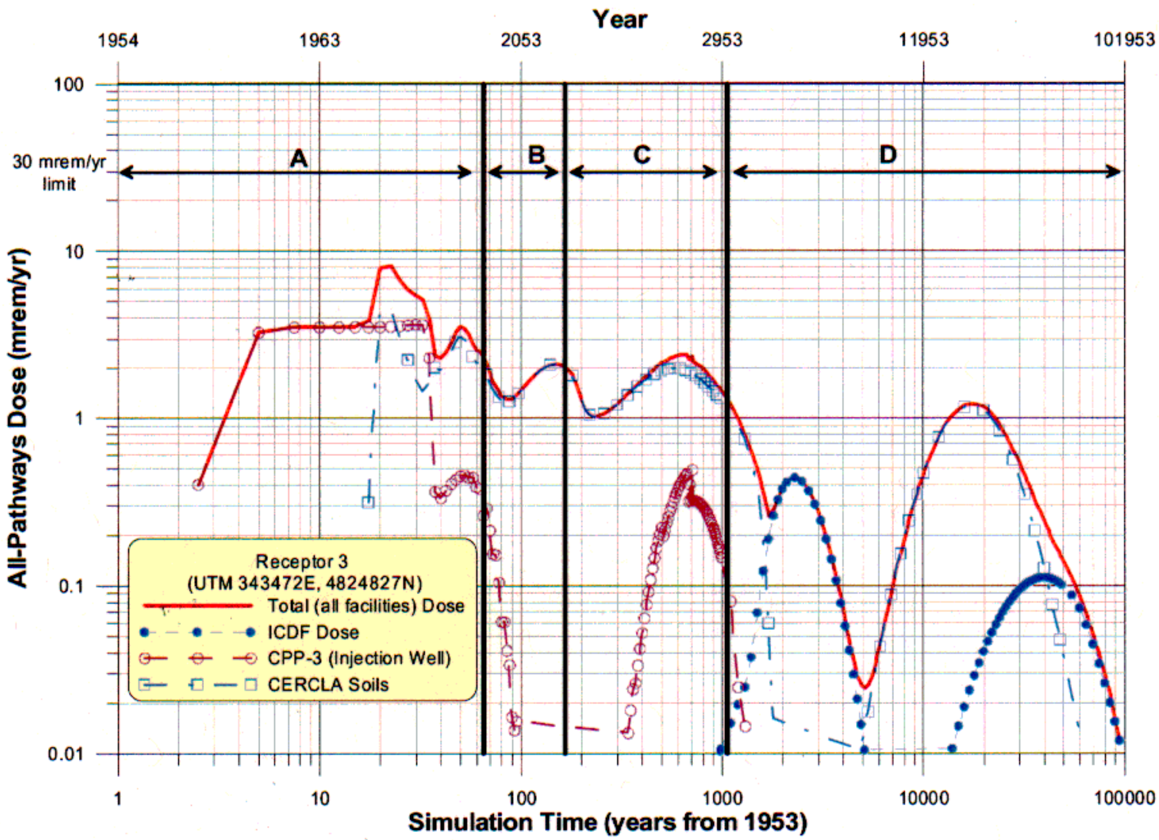

Figure 4-9. Receptor 3 all-pathways dose as a function of time assuming a 0.1-cm/yr infiltration rate through the ICDF cover.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

Table 4-3. Summary of the all-pathways dose analysis for the ICDF landfill CA for sensitivity case that considered the ICDF landfill cover infiltration rate is 1 mm/yr.

Timeframe			Receptor 4	
2018–2118	Year of maximum all-pathways dose		2018	
	Maximum all-pathways dose (mrem/yr)		7.80	
	Percent of dose from each source at time of maximum dose			
	ICDF		0.00%	
	INTEC injection well (CPP-3)		88.03%	
	CPP-601		0.00%	
	CPP-603		0.00%	
	WCF (CPP-633)		0.00%	
	NWCF (CPP-659)		0.00%	
	Tank farm closure		0.00%	
	CERCLA soils		11.97%	
	Tank farm bin sets		0.00%	
	Radionuclide contributions at time of maximum dose:			
	Am-241		0.00%	
	C-14		0.00%	
	I-129		100.00%	
	Np-237		0.00%	
	Pu-239		0.00%	
	Pu-240		0.00%	
	Tc-99		0.00%	
	U-234		0.00%	
	U-238		0.00%	
Timeframe		Receptor 1	Receptor 2	Receptor 3
2118–3018	Year of maximum all-pathways dose	2623	2583	2593
	Maximum all-pathways dose (mrem/yr)	0.42	8.12	2.41
	Percent of dose from each source at time of maximum dose:			
	ICDF	4.65%	0.00%	0.06%
	INTEC injection well (CPP-3)	6.22%	28.43%	18.02%
	CPP-601	0.00%	0.00%	0.00%
	CPP-603	0.00%	0.00%	0.00%
	WCF (CPP-633)	0.00%	0.00%	0.00%
	NWCF (CPP-659)	0.00%	0.00%	0.00%
	Tank farm closure	0.00%	0.00%	0.00%
	CERCLA soils	89.13%	71.57%	81.92%
	Tank farm bin sets	0.00%	0.00%	0.00%

Table 4-3. (continued).

Timeframe		Receptor 1	Receptor 2	Receptor 3
	Radionuclide contributions at time of maximum dose:			
	Am-241	0.00%	0.03%	0.00%
	C-14	0.00%	0.00%	0.00%
	I-129	4.62%	0.00%	0.06%
	Np-237	67.62%	54.05%	61.95%
	Pu-239	5.50%	25.11%	15.93%
	Pu-240	0.72%	3.29%	2.09%
	Tc-99	0.03%	0.00%	0.00%
	U-234	11.52%	9.40%	10.71%
	U-238	9.98%	8.12%	9.27%
Timeframe		Receptor 1	Receptor 2	Receptor 3
3018–100,000	Year of maximum all-pathways dose	4253	19,953	19,953
	Maximum all-pathways dose (mrem/yr)	4.50	3.56	1.21
	Percent of dose from each source at time of maximum dose			
	ICDF	100.00%	0.19%	2.39%
	INTEC injection well (CPP-3)	0.00%	0.00%	0.00%
	CPP-601	0.00%	0.00%	0.00%
	CPP-603	0.00%	0.00%	0.00%
	WCF (CPP-633)	0.00%	0.00%	0.00%
	NWCF (CPP-659)	0.00%	0.15%	0.00%
	Tank farm closure	0.00%	0.00%	0.00%
	CERCLA soils	0.00%	97.53%	97.60%
	Tank farm bin sets	0.00%	2.13%	0.00%
	Radionuclide contributions at time of maximum dose:			
	Am-241	0.00%	0.00%	0.00%
	C-14	0.00%	0.00%	0.00%
	I-129	98.01%	0.00%	0.00%
	Np-237	0.00%	2.12%	0.70%
	Pu-239	0.00%	83.66%	83.73%
	Pu-240	0.00%	13.86%	13.88%
	Tc-99	1.99%	0.00%	0.00%
	U-234	0.00%	0.32%	1.34%
	U-238	0.00%	0.03%	0.36%

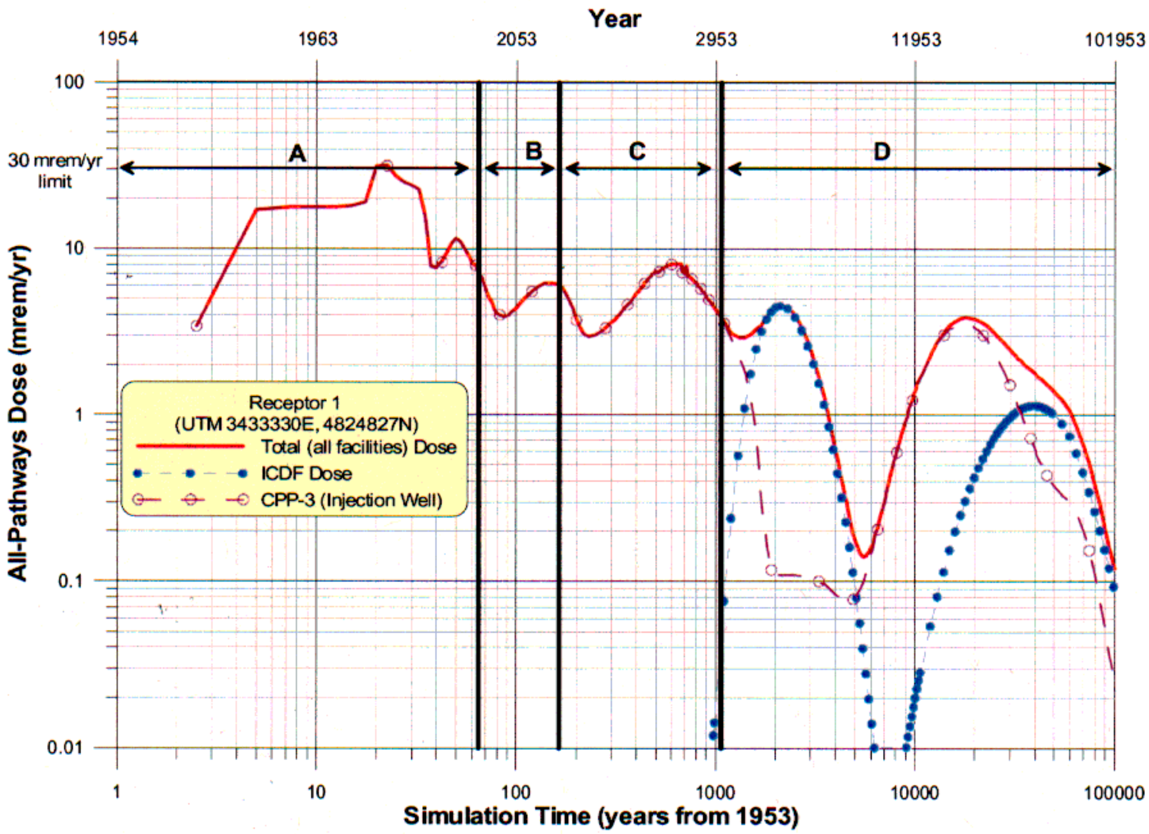

Figure 4-10. Total all-pathways dose assuming the INTEC facilities are directly upgradient of the ICDF.

Note: The letters at the top of the graph refer to the following time periods: A = pre-ICDF (1965–2018), B = institutional control period (2018–2118), C = compliance period (year 2118–3018), D = postcompliance period (>year 3018).

4.5 Limited Sensitivity Analysis Summary

Table 4-4 contains a summary of the sensitivity analyses presented in this section compared with the base case results shown in Section 3.5. The results in the table are color-coded by the sensitivity analysis performed for easier reference.

The simulation of all-pathways dose results assuming that the infiltration-reducing cover on the ICDF landfill fails in 100 years instead of the base case cover failure of 500 years indicates the all-pathways dose results increase during the compliance period from 0.4 mrem/yr to 3.3 mrem/yr at Receptor 1. The failure of the ICDF landfill cover in 100 years versus 500 years does not significantly change the predicted peak all-pathways doses but does move the peak dose at Receptor 1 forward in time. In any case, there is no predicted dose in the compliance control period that approaches the CA compliance dose of 100 mrem/yr or the required options analysis dose constraint of 30 mrem/yr.

The simulation results assuming that the CERCLA soils K_d for plutonium decreases from 220 mL/g to 22 mL/g in the contaminated surface soils and the vadose zone interbeds results in an increase in the all-pathways dose during the compliance and postcompliance periods for all three receptors, with the peak occurring roughly 500 years later than when the peak occurred for the base case. Although a plutonium K_d of 22 mL/g would significantly increase the aquifer all-pathways dose, the receptor locations where the dose is significantly higher have a small contribution from the ICDF landfill.

The sensitivity of the predicted peak dose to the direction of flow in the aquifer was evaluated by assuming that the centerline of the primary plume from the sources at INTEC moves directly to the ICDF landfill and the peak predicted doses sum without any concentration reduction from dispersion. The doses in this sensitivity case did not change from the base case because each source arrives at the aquifer at a different time; therefore, their contaminant plumes do not appear to overlap each other. Thus, having the INTEC facilities directly upgradient of the ICDF landfill does not affect the overall dose from INTEC.

Table 4-4. Summary of the base case and sensitivity results for the all-pathways dose.

Timeframe		Receptor 1	Receptor 2	Receptor 3	Receptor 4
Section 3.5 Base Case All-pathways Dose Results					
2018–2118	Year of maximum all-pathways dose	—[a]	—[a]	—[a]	2018
	Maximum all-pathways dose (mrem/yr)	**—[a]**	**—[a]**	**—[a]**	**7.80**
	ICDF all-pathways dose % contribution	—[a]	—[a]	—[a]	0.00%
2118–3018	Year of maximum all-pathways dose	2583	2583	2593	—[a]
	Maximum all-pathways dose (mrem/yr)	**0.40**	**8.12**	**2.41**	**—[a]**
	ICDF all-pathways dose % contribution	0.04%	0.00%	0.00%	—[a]
3018–100,000	Year of maximum all-pathways dose	4053	19,953	19,953	—[a]
	Maximum all-pathways dose (mrem/yr)	**4.55**	**3.56**	**1.21**	**—[a]**
	ICDF all-pathways dose % contribution	99.99%	0.00%	2.46%	—[a]
Section 4.1 Sensitivity to ICDF Cover Failure at 100 Years					
2018–2118	Year of maximum all-pathways dose	—[a]	—[a]	—[a]	2018
	Maximum all-pathways dose (mrem/yr)	**—[a]**	**—[a]**	**—[a]**	**7.80**
	ICDF all-pathways dose % contribution	—[a]	—[a]	—[a]	0.00%
2118–3018	Year of maximum all-pathways dose	3018	2583	2613	—[a]
	Maximum all-pathways dose (mrem/yr)	**3.34**	**8.12**	**2.43**	**—[a]**
	ICDF all-pathways dose % contribution	93.24%	0.00%	1.13%	—[a]
3018–100,000	Year of maximum all-pathways dose	3453	19,953	3153	—[a]
	Maximum all-pathways dose (mrem/yr)	**4.59**	**3.56**	**1.32**	**—[a]**
	ICDF all-pathways dose % contribution	98.29%	0.00%	27.65%	—[a]
Section 4.2 Sensitivity to CERCLA Soils Plutonium Kd Value					
2018–2118	Year of maximum all-pathways dose	—[a]	—[a]	—[a]	2018
	Maximum all-pathways dose (mrem/yr)	**—[a]**	**—[a]**	**—[a]**	**7.80**
	ICDF all-pathways dose % contribution	—[a]	—[a]	—[a]	0.00%
2118–3018	Year of maximum all-pathways dose	3018	3018	3018	—[a]
	Maximum all-pathways dose (mrem/yr)	**2.40**	**36.94**	**12.49**	**—[a]**
	ICDF all-pathways dose % contribution	3.18%	0.00%	0.06%	—[a]
3018–100,000	Year of maximum all-pathways dose	3953	3753	3753	—[a]
	Maximum all-pathways dose (mrem/yr)	**8.90**	**69.82**	**24.14**	**—[a]**
	ICDF all-pathways dose % contribution	49.99%	0.00%	1.54%	—[a]
Section 4.3 Sensitivity to Cover Infiltration 10X the Base Case					
2018–2118	Year of maximum all-pathways dose	—[a]	—[a]	—[a]	2018
	Maximum all-pathways dose (mrem/yr)	**—[a]**	**—[a]**	**—[a]**	**7.80**
	ICDF all-pathways dose % contribution	—[a]	—[a]	—[a]	0.00%
2118–3018	Year of maximum all-pathways dose	2623	2583	2593	—[a]
	Maximum all-pathways dose (mrem/yr)	**0.42**	**8.12**	**2.41**	**—[a]**
	ICDF all-pathways dose % contribution	4.65%	0.00%	0.06%	—[a]
3018–100,000	Year of maximum all-pathways dose	4253	19,953	19,953	—[a]
	Maximum all-pathways dose (mrem/yr)	**4.50**	**3.56**	**1.21**	**—[a]**
	ICDF all-pathways dose % contribution	100.00%	0.19%	2.39%	—[a]

a. Not a compliance point.

5. PERFORMANCE EVALUATION

In this section, ICDF landfill CA doses presented in Sections 3 and 4 are compared with performance objectives. Implications of the ICDF landfill CA results on INEEL land-use planning, site characterization, and environmental monitoring are also discussed where applicable.

Performance objectives in DOE O 435.1 are stated in terms of a radiological dose limit to a hypothetical member of the general public. This person resides at a publicly accessible location where the maximum radionuclide concentrations in groundwater are expected to occur. The receptor location for the ICDF is the INEEL boundary for an institutional control period of 100 years and 100 m downgradient of the ICDF for the following 900 years (compliance period). Performance objectives also include a comparison of groundwater concentrations with MCLs as stated in 40 CFR 141. Performance objectives are summarized as follows:

- The DOE primary dose limit of 100 mrem/yr.
- The DOE dose constraint of 30 mrem/yr. If the base case dose exceeds 30 mrem/yr, an options analysis must be completed.
- The committed dose equivalent for man-made beta-gamma-emitting nuclides does not exceed 4 mrem/yr as derived from current MCLs.
- MCL for Ra-226 and Ra-228 (5 pCi/L).
- MCL for gross alpha activity excluding uranium and radon but including Ra-226 (15 pCi/L).
- The proposed MCL for total uranium (20 µg/L).

5.1 Comparison of Results to Performance Objectives

As shown in Table 3-3, the ICDF landfill does not become a significant dose contributor to any of the three receptor locations until after the year 3000 (see Figure 3-1 for receptor locations). Beyond 1000 years, the ICDF landfill becomes the major dose contributor at Receptor 1, a minor contributor at Receptor 3, and never contributes at Receptor 2. However, for purposes of comparison with the performance objectives, the maximum concentration at either Receptor 1, 2, or 3 is compared to performance objectives for the compliance period (2118-3018). During the institutional control period, only Receptor 4 at the site boundary is evaluated.

5.1.1 Institutional Control Period—Year 2018 to Year 2118

During the institutional control period, the public receptor is at the INEEL site boundary (Receptor 4 location), which is about 15 km (9 mi) south of the INTEC facility. The predicted concentrations and associated doses during the institutional control period at Receptor 4 are summarized below and shown in Table 5-1.

- The predicted groundwater all-pathways dose is 7.8 mrem/yr occurring in the year 2018, which is the year the ICDF landfill will be closed. Since there are no releases from the ICDF landfill before 2018, this dose is entirely from the other INTEC facility sites. This value is insignificant compared to the DOE primary dose limit of 100 mrem/yr and the CA dose constraint for an options analysis of 30 mrem/yr.

Table 5-1. Comparison of results with performance objectives for all-pathways and groundwater protection.

Performance Objective	Regulatory Reference	Institutional Control Period (Receptor 4)	Compliance Period Until the Year 3018 (Receptor 2)	Postcompliance Period Until the Year 100,000 (Receptor 1)
100 mrem/yr (DOE primary dose limit) and 30 mrem/yr (DOE CA dose limit for options analysis)	All-pathways	7.8 mrem/yr	8.1 mrem/yr	4.6 mrem/yr
4 mrem/yr man-made beta-gamma CDE[a]	Groundwater protection	69 mrem/yr	0.19 mrem/yr	40 mrem/yr
5 pCi/L Ra-226 and Ra-228 concentration[a]	Groundwater protection	0.0 pCi/L	2.6E-04 pCi/L	0.029 pCi/L
15 pCi/L adjusted gross alpha concentration[a]	Groundwater protection	0.0 pCi/L	2.1 pCi/L	1.3 pCi/L
20 µg/L uranium concentration[a]	Groundwater protection	0.00 µg/L	9.5 µg/L	5.5 µg/L

a. Derived from current and proposed MCLs.

- The predicted peak committed dose equivalent from ingestion of man-made beta-gamma-emitting nuclides in drinking water is 69 mrem/yr during the institutional control period. This dose is significantly higher than the 4 mrem/yr limit. This high dose is due primarily to the conservative source term assumption for the INTEC disposal well used in the modeling. This has been discussed previously in greater detail in Section 3.7.2.

- The predicted peak cumulative Ra-226 and Ra-228 concentration is 0 pCi/L during the institutional control period. This concentration is significantly less than the 5-pCi/L MCL.

- The predicted peak adjusted gross alpha concentration is 0 pCi/L during the institutional control period. This concentration is significantly less than the 15-pCi/L MCL.

- The predicted peak uranium concentration is 0 µg/L during the institutional control period. This concentration is significantly less than the 20-µg/L MCL.

During the institutional control period, until year 2118, the predicted radionuclide concentrations and associated peak doses are all below the groundwater protection performance objectives and the dose constraint for an options analysis with the exception of the beta-gamma dose of 69 mrem/yr, which is well above the 4 mrem/yr groundwater protection limit.

5.1.2 Compliance Period—Year 2118 to Year 3018

During the compliance period, the public receptor is located 100 m (328 ft) from the ICDF landfill boundary. The results presented in this section are from Receptor 2 because the total dose (attributed to CERCLA soils and injection well) is less at Receptor 1 and Receptor 3. The predicted concentrations and associated doses with respect to the groundwater protection objectives for the compliance period up until year 3018 are summarized below and shown in Table 5-1:

- The maximum predicted groundwater all-pathways dose is 8.1 mrem/yr prior to the year 3018. The peak occurs well before any significant dose from the ICDF landfill reaches the aquifer. This value is less than both the DOE primary dose limit of 100 mrem/yr and the CA dose constraint of 30 mrem/yr that triggers an options analysis.

- The predicted peak committed dose equivalent from ingestion of man-made beta-gamma-emitting nuclides in drinking water is 0.19 mrem/yr during the compliance period. This dose is significantly less than the 4-mrem/yr limit.

- The predicted peak cumulative Ra-226 and Ra-228 concentration is 2.6E-04 pCi/L, which is significantly less than the 5-pCi/L MCL.

- The predicted peak adjusted gross alpha concentration is 2.1 pCi/L, which is significantly less than the 15-pCi/L MCL.

- The predicted peak uranium concentration is 9.5µg/L, which is significantly less than the 20-µg/L MCL.

During the compliance period, until year 3018, the predicted radionuclide concentrations and associated peak doses are significantly below the groundwater protection performance objectives and the dose constraint for an options analysis.

5.1.3 Postcompliance Period Until Predicted Peak Dose

During the postcompliance period, the public receptor is located 100 m (328 ft) from the ICDF landfill boundary. The results presented in this section are from Receptor 1 because the total dose (now attributed to the ICDF Landfill I-129 disposals) is less at Receptor 3 and Receptor 2 whose total dose is influenced mainly by the CERCLA soils source term. The predicted concentrations and associated doses with respect to the groundwater protection objectives from the end of the compliance period (year 3018) up until year 100,000 are summarized below and shown in Table 5-1:

- The maximum predicted groundwater all-pathways dose is 4.6 mrem/yr, which is much less than the DOE primary dose limit of 100 mrem/yr and the dose constraint for an options analysis of 30 mrem/yr. The primary contributor to the all-pathways dose during this time period is I-129 (98%) from the ICDF landfill.

- The predicted peak committed dose equivalent from ingestion of man-made beta-gamma-emitting nuclides in drinking water is 40 mrem/yr during the postcompliance period. This dose is 10 times the 4-mrem/yr limit. This dose is attributed to the ICDF Landfill I-129 disposal source estimates.

- The predicted peak cumulative Ra-226 and Ra-228 concentration is 0.029 pCi/L, which is significantly less than the 5-pCi/L MCL.

- The predicted peak adjusted gross alpha concentration is 1.3 pCi/L, which is significantly less than the 15-pCi/L MCL.

- The predicted peak uranium concentration is 5.5 µg/L, which is significantly less than the 20-µg/L MCL.

During the total simulation period, until year 100,000, the predicted radionuclide concentrations and associated peak doses are significantly below the groundwater protection or performance dose objectives and the CA dose constraint for an options analysis, with the exception of the beta-gamma dose of 40 mrem/yr which is 10 times the limit of 4 mrem/yr.

5.1.4 Summary

The findings indicate that the all-pathways dose is well below the 30-mrem/yr dose constraint and the 100-mrem/yr dose limit as prescribed in DOE O 435.1 for all times in the future. Furthermore, doses from the ICDF landfill during the institutional control and compliance period (year 2018 to 3018) are miniscule (less than 0.01 mrem/yr) and, therefore, cannot seriously impact any of the doses from preexisting sources at INTEC. Even under the most pessimistic of assumptions, that is, if the ICDF cover fails at 100 years and all INTEC sources lie along the same flow path as the ICDF landfill, the all-pathways dose during the 0- to 1,000-year compliance period is still below the 30-mrem/yr dose constraint and 100-mrem/yr primary dose limit.

5.2 Options Analysis

Consistent with international and national recommendations, the DOE radiation protection system encompasses two principal elements: dose limits and optimization.

- Dose limits constitute allowable or tolerable doses that are not to be exceeded under normal conditions. The 100-mrem/yr all-pathways dose is the primary dose limit for protection of the public from all sources and pathways. DOE also employs dose constraints in the implementation of the radiation protection system. The dose constraint of 30 mrem/yr, which is set at a fraction of the primary dose limit, is established to ensure that no single source, practice, or pathway uses an extraordinary portion of the primary dose limit.

- Optimization effectively reduces public doses to levels as far below dose limits or constraints as is practicable, giving due consideration to collective impacts, costs, and other factors, using the ALARA process.

The CA process incorporates the elements of the radiation protection system as benchmarks to aid environmental management. The CA uses long-term projections of potential doses to support systematic environmental management of waste management and restoration sites. Two decision criteria, based on whether results exceed the dose constraint or the primary dose limit, are used in considering the implications of the CA results:

- The first decision criterion evaluates if the potential exists for the total dose from the CA to be greater than the dose limit of 100 mrem/yr. If so, the potential future problem must be corrected or mitigated before it occurs. In this case, an options analysis must be conducted to identify alternatives for reducing future doses (before they occur) to tolerable levels.

- If no potential exists for the total dose from the CA to be greater than the dose limit of 100 mrem/yr, then the CA results must be reviewed to determine if the potential exists for exceeding the DOE dose constraint of 30 mrem/yr. If so, the options analysis must be conducted and the alternatives considered for determining what actions are reasonable to reduce potential future public doses.

The difference between exceeding the 100-mrem/year dose criteria and the 30-mrem/year options analysis criteria is that, in the first case, mitigating measures must be taken before the dose limit is exceeded, while in the second case, an action could be taken but may be determined not to be warranted.

The composite analysis is an assessment of the cumulative impacts from the active LLW disposal facility and from all other sources of radioactive contamination that could interact with possible releases from the LLW disposal facility in causing a dose to future members of the public. The highest projected annual dose over the 1,000 years following closure of the active facility to a hypothetical member of the public from all INEEL sources that could interact in that manner is documented in Section 3 to be approximately 10 mrem/yr and is influenced mainly by other INTEC sources and negligible influence from the ICDF landfill. The predicted peak all-pathways dose for the ICDF landfill CA is less than both the 100-mrem/yr dose limit and the 30-mrem/yr options analysis dose constraint. Therefore. there is no requirement to conduct an options analysis. Since, the ICDF landfill is not a major contributor to the projected dose to the hypothetical receptor, the ICDF landfill facility design and Waste Acceptance Criteria will be based on the DOE M 435.1-1 performance assessment and not influenced by the CA.

However, for composite analyses that demonstrate predicted results that are less than the dose constraint of 30 mrem/yr for the disposal facility and all other contributing sources, the need for an ALARA assessment is presented and an ALARA assessment is performed if required.

The ICDF Landfill Performance Assessment (DOE-ID 2003a) all-pathways dose was estimated to be 0.05 mrem/yr. Several options for reducing these doses were evaluated in an ALARA analysis presented in the assessment and are briefly summarized below.

Options evaluated for reducing potential doses included (1) removal, treatment, and off-Site disposal, (2) the use of high-integrity containers, and (3) use of an engineered landfill liner and leachate collection system. Other options mentioned that could also be considered include extending the period of institutional control and expanding the areal extent of institutional control. However, both of these options are written into the ROD (DOE-ID 1999) should the ICDF pose a threat to human health and the environment.

In summary, the ALARA analysis concluded the proposed waste disposal practices at the ICDF landfill will be protective of human health and the environment with extremely small estimate of dose to members of the public relative to background levels. Several options were evaluated for reducing these doses but, based on a monetary equivalence of $1,000 to $10,000 per person-rem, most options will probably not be cost-effective from an ALARA standpoint.

5.3 Use of Composite Analysis Results

The results of the ICDF landfill CA are used for comparison with the performance objectives and to show that the Waste Acceptance Criteria for the ICDF landfill are protective. Waste Acceptance Criteria have been developed (DOE-ID 2002b) and results from the PA (DOE-ID 2003a) and this CA will be used to modify the WAC. Given the current total inventory limits and Waste Acceptance Criteria, the results of the CA indicate the planned disposals are acceptable. If the inventory limits are significantly increased, the assumptions and results of this CA will have to be reevaluated.

As with the ICDF PA (DOE-ID 2003a), the results of this ICDF landfill CA will be used in the development of an environmental monitoring plan and an action plan. Because this is a radioactive waste management facility, it will meet the environmental monitoring requirements of DOE O 231.1, "Safety and Health Reporting Requirements"; DOE O 5400.5, "Radiation Protection of the Public and the Environment"; and DOE O 435.1, "Radioactive Waste Management." The monitoring will be designed to verify that the facility is performing as planned and that the transport of contaminants from other sources is consistent with the report assumptions. The action plan will detail what action will be taken if the results of the monitoring indicate the ICDF landfill is not performing as expected or that transport from the related CA sources is greater than expected.

6. FUTURE WORK

The CA for the ICDF landfill is a working document. Annual reports will be used to evaluate new information with respect to the assumptions made in this CA, as well as the PA. If there are major changes to the assumptions, then the performance of the ICDF landfill will be reevaluated. Future work will include, but not be limited to, the following:

- Routine subsurface monitoring of the contaminants of concern and indicator contaminants will be continued. Any unexpected results will be evaluated for impact on the conclusions of this CA.

- During disposal to the ICDF landfill, radiological soil surveys will be conducted and the projected radionuclide inventory will be refined accordingly. This will include sampling of the soils before disposal to the ICDF landfill and reestimation of the inventory.

- Because the prediction of flow and transport in the vadose zone has a high level of uncertainty, a tracer test is currently underway. Tracers have been introduced in the INTEC percolation pond and the sewage treatment pond. In the future, when sufficient water is running in the Big Lost River, a tracer will be introduced in the river as well. The objective of the study is to follow the transport of the tracer through the vadose zone. The study will provide new information on (1) the horizontal spreading of contaminants in the vadose zone in the vicinity of surface water sources, (2) the velocity of movement in the horizontal directions, (3) the vertical transport velocity, and (4) the total travel time from the surface to the aquifer under relatively well-defined water flux conditions.

- The subsurface science initiative at the INEEL is actively involved in research to better understand the mechanisms controlling flow and transport of contaminants in the subsurface. The results of this research could modify the conceptual model upon which the ICDF landfill analyses are based. Therefore, the research progress will be monitored and results incorporated into the PA and CA annual reviews, if the assumptions are significantly impacted/changed. Examples of areas of interest include

    - Unsaturated hydraulic parameters

    - Distribution coefficients in sediments, basalt matrix, vertical fractures in the vadose zone, and rubble zones in the aquifer

    - Flow and transport in fractures

    - Flow and transport interactions at basalt-sediment interfaces

    - Facilitated transport

    - Performance of infiltration-reducing covers on disposal facilities

    - Source term releases as influenced by geochemistry

    - Testing and development of new and better ways to measure parameters and monitor the movement of contaminants in the subsurface.

- A coordinated monitoring, testing, and research plan will be developed as part of performance assessment and CA maintenance.

- For future facility closures and DD&D, the CA will be updated as future sites are closed and new source terms estimated. In addition, the closure of future sites can use results in this CA to help define acceptable levels of cleanup.

7. PREPARERS

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Dr. McCarthy has 14 years of experience related to groundwater hydrology, surface water hydrology, and water resource systems. During the last 11 years he has focused his efforts on performance assessment and risk assessment related projects. He has been the principal investigator on a number of environmental restoration and waste management related subsurface flow and transport studies including most recently, the CA evaluation for a low-level radioactive waste disposal facility at the Radioactive Waste Management Complex, at the Idaho National Engineering and Environmental Laboratory.

For this Composite Analysis, Dr. McCarthy has been one of the principal investigators contributing to the project coordination, technical aspects, as well as document preparation.

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Ms. Keck is an advisory scientist for Bechtel BWXT Idaho with 20 years of experience in the field of surface water and groundwater hydrology and hazardous waste management. She prepares surface-water storm evaluation studies for RCRA Part B permitting of hazardous waste storage facilities. She has performed hydrologic modeling of landfill cover designs for a mixed-waste landfill using EPA code HELP. She has prepared several human health risk assessments in support of CERCLA/RCRA investigations. More recently she was involved in the technical aspects and overall document preparation of the INEEL Radioactive Waste Management Complex Composite Analysis and subsequent development of performance assessment and CA action levels, required by DOE Order 435.1.

For this Composite Analysis, Ms. Keck has been one of the principal investigators providing technical assistance and document preparation.

Arthur S. Rood

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Arthur Rood is an environmental engineer and health physicist with over 18 years of experience in developing and applying models of contaminant fate and transport in the environment. He developed the groundwater model used in this performance assessment and also co-authored the food chain model for the MACCS reactor consequence code. Mr. Rood has also been involved in numerous environmental assessments at the INEEL including other performance assessments. Additionally, he performed much of the environmental transport modeling for the Rocky Flats Historical Public Exposures Studies.

Currently, Mr. Rood is an advisory engineer/scientist for Bechtel BWXT Idaho. His achievements over the past two years have included a detailed analysis of subsurface tritium migration at the Radioactive Waste Management Complex. Highly visible projects include a performance assessment of the Radioactive Waste Management Complex and development of waste acceptance criteria, required by DOE Order 435.1.

For this Composite Analysis, Mr. Rood has been one of the principal investigators, focusing on groundwater fate and transport pathways and Monte Carlo uncertainty analysis, as well as document preparation.

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